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An analysis of wind losses to Iowa farm buildings

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AN ANALYSIS OF WIND LOSSES TO IOWA FARM BUILDINGS

BY

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

The Project

History

"An Investigation of Farm Building Losses Due to Wind and Fire," designated as Project 23 by the Agricultural Experiment Station, Iowa State College, is sponsored jointly by the Iowa Mutual Tornado Insurance Association and the Farmers Mutual Reinsurance Association. The project was started in 1930 when the two associations asked the Iowa Agricultural Experiment Station to conduct a study with the view of determining what types of wind and fire losses are most prevalent in Iowa; and what can be done to minimize these losses through improved design of farm buildings, education of farm builders, more frequent inspections, and a more thorough continued maintenance program for the existing farm buildings.

The present study will consider only farm building losses due to wind damage. This portion of the study has previously been divided into six sub-topics. They are:

1. Statistical study
2. Aerodynamics
3. Field observations

4. Structural analysis

5. Laboratory tests

6. Design

In order to analyze most accurately the wind damage to Iowa farm buildings, statistical studies of the types of building failures must be made. The only statistical studies made in Iowa to date were during the period of 1930 to 1933 by Elmer F. Clark (3) and Marvin F. Schweers (15). These data concerning Iowa farm building wind losses are necessarily not up to date.

Building designs have changed and different types of roofing materials and construction methods are being used. Some buildings have been remodeled for changing farm enterprises; and since 1933, a building inspection system has been incorporated, which may or may not have caused definite trends in types of building failures. The inspection system and refusal to insure buildings unless they met certain specifications has been one way of making farm owners conscious of building weaknesses; but as yet standards are lacking by which to set up specifications for which a building must qualify in order to be insurable.

The aerodynamic phase due to its nature requires an expensive layout of equipment to make actual studies. In this project, to date, such studies have been devoted to adapting the results of other investigators concerning the

nature and distribution of wind pressure, to farm buildings.

Field observations have proved very beneficial in determining the exact cause of many building failures and have been made by most investigators. In the field, following a windstorm, actual buildings can be studied and pictures taken for further proof of the weaknesses and exact causes of failure.

Structural analysis studies have been carried on to determine roof shapes which give the greatest stability under dead loads.

Various types of barn rafters have been reproduced to scale and submitted to laboratory tests to formulate data for use in designing and developing new barn plans which are economical in construction and also sufficiently stable to withstand probable Iowa wind storms.

Purpose

The purpose of this study is primarily statistical in nature and will include, accumulation, tabulation, and analysis of recent wind loss data on Iowa farm buildings; and development of a system of tables for the continued annual tabulation of such data. Accumulated ten-year studies are contemplated from which trends can be studies more thoroughly. The question of what is a good risk and what is not will be investigated, with the hope of setting up a more

accurate table of specifications for use in the classification of farm buildings.

Justification of Study

Farm Building investment in Iowa

According to the 1940 United States Census (18), farm buildings in the United States were evaluated at over ten billion dollars; with Iowa listed as the leading state, having one-twelfth of the totel investment or about eight hundred million dollars. This tremendous investment, considered only from a monetary angle, cannot be overlooked, to say nothing of the service that is continually required of these buildings by each and every farm operator in the state of Iowa. The interest, considered at 3 per cent, to maintain this investment, amounts to some twenty-four million dollars annually. Farm buildings are definitely a "must" in the production of agricultural products in Iowa. It is an exception rather than a rule when a product can be prepared for market without having required the direct use of some type of building either for storing or housing.

The question of justification of farm buildings is only a matter of how much can economically be spent for the construction and maintenance of a particular structure, rather than whether the building is required or not. Various farm

enterprises demand certain types of buildings in order that they prove successful.

Regardless of whether all of the expenditure for existing farm buildings or those to be built can be justified or not, it is to our advantage to protect the present investment the best way possible by proper maintenance and inspection, and in some cases redesigning so as to better withstand wind and fire. Proper care tends to lower annual depreciation and lengthen the useful life, thereby lowering the annual cost for the farm buildings.

The new buildings being constructed for new enterprises or to replace old buildings which have ceased to be of service, should be designed rather than merely constructed, as so many of the present ones were. New farm structures should be designed and constructed sufficiently stable to withstand probably windstorms, fire resistant as practicable, economical in construction material and labor, flexible for utilization purposes, convenient to related operations, attractive in the farmstead layout, and adequate to cope with any future expansions which they may be required to accommodate.

In considering the distribution of the Iowa farm building investment, by counties, it was found that the amount varied from slightly over two million dollars in a few southern counties to nearly fifteen million dollars in

Kossuth, the largest county, as evaluated in the 1940 United States Census (18). In using total investment data per county, it was impossible to realize any definite trend in amount of farm building investment as pertains to the various areas of the state. In an attempt to determine if certain farming areas of the state had more invested than other areas, the average investment per farm was tabulated and listed in Table I. Due to the wide variance in the size of counties in Iowa, as compared to the much smaller variance in the size of farms, the average investment per farm for each county showed a much more uniform change in the amount of farm building investment between the various farming areas. As illustrated graphically in Figure 1, the dark and light areas appear in somewhat of a pattern. Figure 2 was prepared to show graphically the variance between farming areas of building investment, risk in force, and average income per worker and farm. The southern pasture area has the lowest building investment per farm. Appanoose County showed the lowest investment with an average of $1,390,000 per farm. The average building investment per farm for the entire southern pasture area was $2,250.00, as compared with an average of $4,310.00 in the central cash grain area, which proved to have only a slightly larger average investment per farm than the northeastern dairy area with $4,230.00. The eastern livestock area was only a little lower with an

Table I

FARM BUILDING INVESTMENT IN 1940, RISH IN FORCE 1927-46, AND WIND LOSS RATIO FOR 1927-46

County	Farm bldg. investment in 1940	Number of farms	Investment per farm	Av. risk per farm 1927-46	Loss ratio '27-'46
Adair	$6,005,354	2,070	$2,900	$1,730	$ .673
Adams	4,277,010	1,548	2,770	1,650	.825
Allamakee	7,715,034	2,060	3,750	2,190	.614
Appanoose	2,814,765	2,026	1,390	310	.359
Audubon	6,624,020	1,794	3,690	3,450	.396
Benton	11,971,017	2,451	4,880	2,470	.572
Black Hawk	11,580,087	2,467	4,690	2,880	.598
Boone	8,704,600	2,404	3,620	3,760	.403
Bremer	9,856,691	2,051	4,810	4,590	.331
Buchanan	8,691,376	2,345	3,710	1,930	.504
Buena Vista	10,182,393	2,065	4,940	6,590	.626
Butler	9,008,177	2,335	3,860	3,970	.453
Calhoun	9,277,765	2,057	4,520	4,250	.599
Carroll	9,687,088	2,044	4,740	1,880	.505
Cass	7,277,513	2,163	3,370	2,200	1.067
Cedar	11,369,992	2,186	5,200	2,360	1.069
Cerro Gordo	8,299,301	1,969	4,210	6,140	.638
Cherokee	8,398,090	1,756	4,780	5,140	.613
Chickasaw	7,681,697	2,005	3,830	4,450	.507
Clarke	2,667,488	1,426	1,880	170	.721
Clay	8,972,295	1,809	4,960	6,980	.626
Clayton	13,724,666	2,942	4,670	4,680	.274
Clinton	12,114,719	2,606	4,660	1,500	.664
Crawford	11,006,630	2,467	4,470	310	.471
Dallas	8,378,082	2,357	3,560	2,320	.645
Davis	3,487,219	1,829	1,910	60	.795
Decatur	3,184,010	1,876	1,700	120	.374
Delaware	10,510,122	2,219	4,740	2,580	.373
Des Moines	5,769,172	1,711	3,370	1,890	.332
Dickinson	4,625,774	1,226	3,780	4,780	1.180
Dubuque	11,098,600	2,276	4,880	940	.502
Emmet	5,013,017	1,253	4,070	4,720	1.161

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Table I (cont'd)

County	Farm bldg. investment in 1940	Number of farms	Investment per farm	Av. risk per farm 1927-46	Loss ratio '27-'46
Fayette	$11,090,589	3,067	$3,620	$3,380	$ .551
Floyd	8,012,589	1,870	4,290	4,570	.897
Franklin	9,886,454	2,118	4,660	6,140	.416
Fremont	5,149,668	1,691	3,060	1,440	.861
Greene	8,420,339	2,101	4,000	3,760	.464
Grundy	8,719,878	1,765	4,940	4,480	.558
Guthrie	6,468,419	2,346	2,760	1,460	.555
Hamilton	9,943,466	2,098	4,740	2,740	.719
Hancock	8,856,091	1,943	4,560	5,760	.716
Hardin	8,939,042	2,008	4,450	5,060	.302
Harrison	6,508,631	2,567	2,540	2,950	.581
Henry	6,348,287	1,810	3,500	1,930	.558
Howard	6,486,532	1,733	3,750	3,890	.616
Humboldt	7,242,164	1,404	5,160	6,890	.317
Ida	6,648,054	1,324	5,000	2,810	.354
Iowa	8,919,406	2,116	4,210	3,310	1.244
Jackson	8,460,811	2,202	3,840	1,980	.654
Jasper	11,032,302	2,905	3,790	3,340	.962
Jefferson	5,158,035	1,755	2,950	1,490	.453
Johnson	11,326,544	2,530	4,480	2,200	.706
Jones	9,676,521	2,115	4,580	2,550	.459
Keokuk	7,701,312	2,468	3,130	2,160	.597
Kossuth	14,888,392	3,039	4,910	5,020	.590
Lee	5,934,381	2,043	2,900	550	.324
Linn	13,484,440	3,680	3,670	2,000	.482
Louisa	4,473,274	1,260	3,550	1,350	.378
Lucas	3,055,593	1,645	1,860	790	.942
Lyon	7,482,951	1,834	4,080	5,980	1.406
Madison	5,796,668	2,066	2,810	1,660	.566
Mahaska	8,646,070	2,701	3,200	1,060	.436
Marion	5,613,990	2,404	2,340	700	.771
Marshall	10,335,494	2,264	4,570	3,460	.340
Mills	4,632,931	1,460	3,180	2,710	.863

Continued on next page

Table I (Cont'd)

County	Farm bldg. investment in 1940	Number of farms	Investment per farm	Av. risk per farm 1927-46	Loss ratio '27-'46
Mitchell	$ 7,106,804	1,696	$4,190	$5,570	$ .420
Monona	6,145,604	2,046	3,000	1,470	.570
Monroe	2,575,150	1,607	1,610	50	.676
Montgomery	5,474,058	1,587	3,460	2,200	.725
Muscatine	7,650,571	1,706	4,490	3,130	.652
O'Brien	10,346,390	1,931	5,360	9,120	.708
Osceola	5,591,165	1,285	4,350	5,190	.607
Page	7,287,227	2,054	3,560	1,710	.396
Palo Alto	7,230,252	1,832	3,940	4,430	.702
Plymouth	11,729,125	2,789	4,220	4,770	.502
Pocahontas	9,713,200	1,971	4,930	6,790	.735
Polk	9,758,957	3,074	3,180	1,960	.601
Pottawat'mie	13,396,821	3,176	3,610	4,770	.626
Poweshiek	8,399,508	2,103	3,990	4,070	.478
Ringgold	3,766,737	1,806	2,090	520	.877
Sac	9,424,916	2,008	4,700	5,980	.603
Scott	12,724,223	2,265	5,640	1,080	.722
Shelby	8,176,402	2,094	3,910	5,190	.531
Sioux	11,642,486	2,978	3,920	6,310	1.246
Story	9,298,812	2,237	4,160	1,650	.609
Tama	12,088,512	2,684	4,510	3,020	.224
Taylor	5,283,363	2,146	2,470	1,470	.502
Union	3,348,914	1,583	2,120	410	1.016
Van Buren	3,459,065	1,741	2,010	900	.324
Wapello	4,688,600	1,959	2,400	410	.666
Warren	5,236,173	2,382	2,200	770	.675
Washington	9,556,498	2,239	4,270	550	.351
Wayne	3,334,386	1,716	1,940	600	.501
Webster	10,888,573	2,622	4,150	5,300	.803
Winnebago	6,665,722	1,613	4,140	5,820	.522
Winneshiek	11,962,264	2,862	4,180	3,980	.573
Woodbury	10,237,892	3,118	3,290	2,100	.966
Worth	6,459,816	1,495	4,330	6,630	.453
Wright	8,803,596	1,967	4,490	4,000	1.175
Total	$794,901,864				

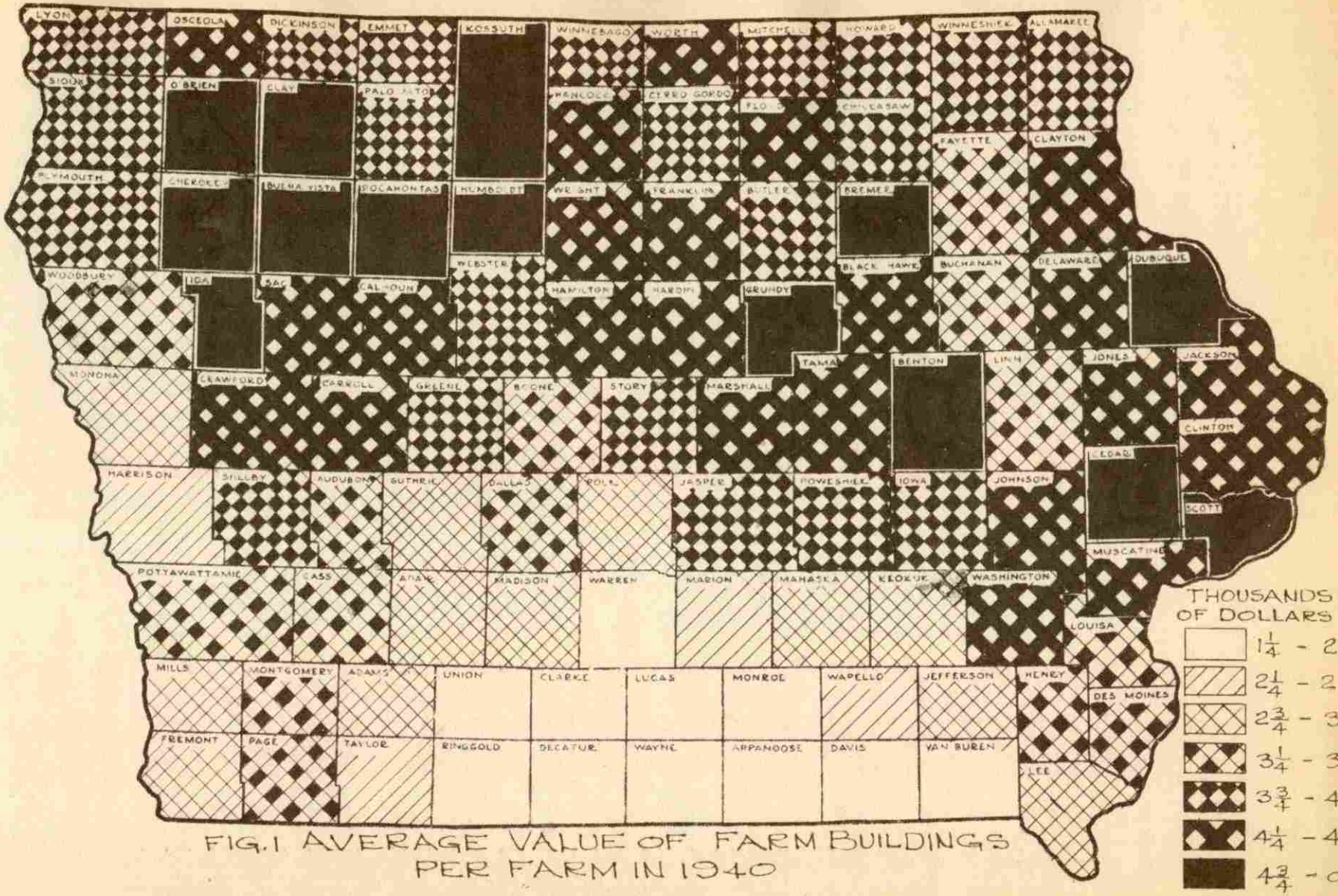

FIG. 1 AVERAGE VALUE OF FARM BUILDINGS PER FARM IN 1940

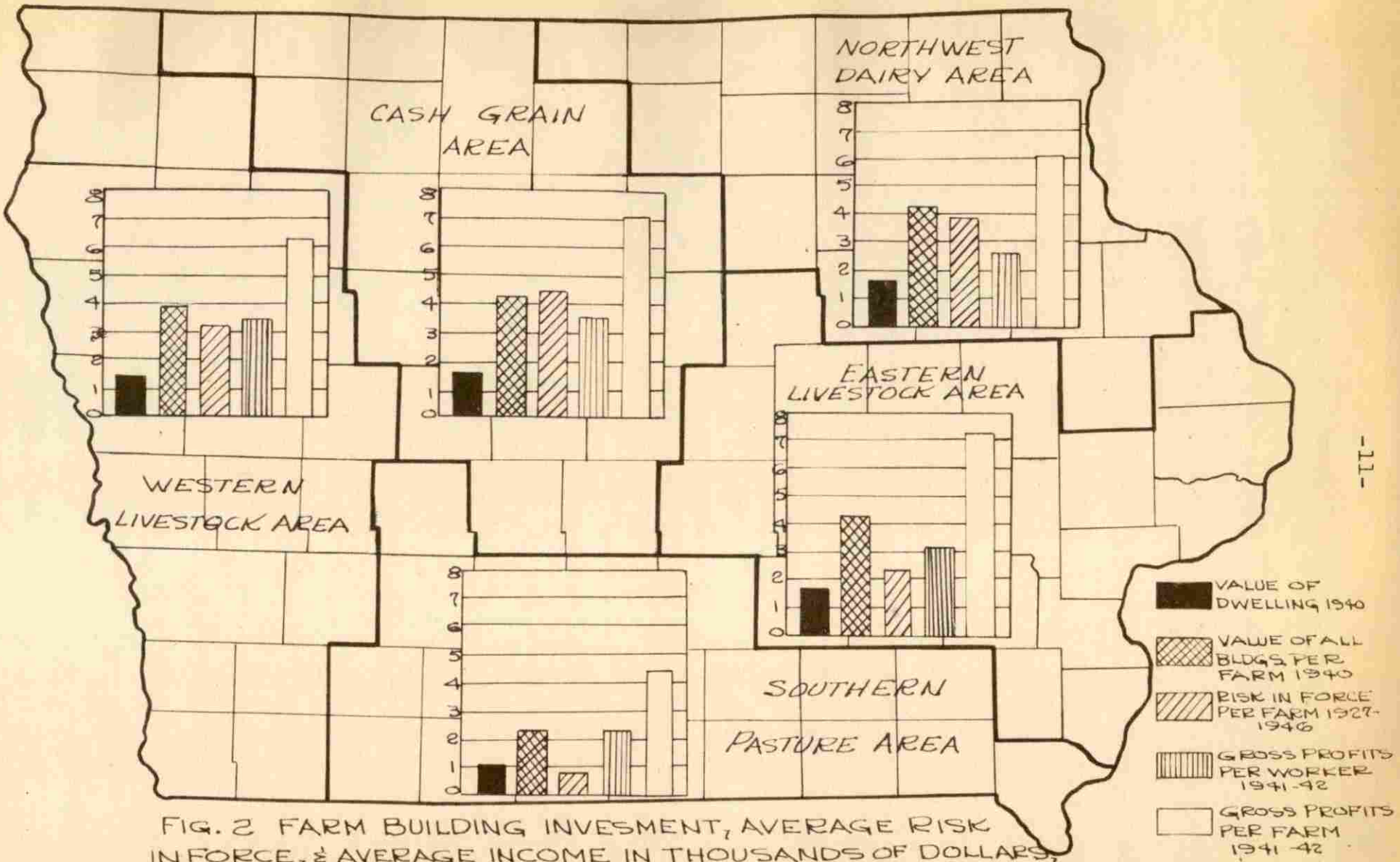

FIG. 2 FARM BUILDING INVESMENT, AVERAGE RISK IN FORCE, & AVERAGE INCOME IN THOUSANDS OF DOLLARS, BY FARMING AREA

average investment of $4,190.00, while that for the western livestock area was $3,940.00 per farm.

The distribution of the investment in farm buildings in Iowa varies quite definitely between the different types of farm areas, as shown in Figure 2. The variance seems to be related to the types of farming, the value of land, and the gross profits per farm worker in the different farming areas of the state.

The southern pasture area has the lowest average investment in farm buildings per farm due mainly to the nature of the farming enterprise. A large per cent of the land is in permanent pasture, fewer cash crops are grown, the gross income per farm and per worker is low as illustrated by Figure 2, in comparison with other areas of the state. The somewhat milder climate also reduces the requirement for expensive farm buildings.

In contrast, the farm building investment is the highest in the cash grain area with an average of $4,310.00 per farm and an average of $1,660.00 per farm invested in the farm dwelling alone. Although the name indicates an area which produces mainly grains for cash sales, the income for the sale of hogs actually is larger than that for the sale of grains. This fact indicates the necessity for livestock buildings in the area in order that their main farm enterprise can be carried on. The average gross profits per worker for 1941 and 1942 were the highest of any of the other farming

areas, being $3,640.00 annually. The value of land is also the highest in the cash grain area, being valued at $16,460 per 200-acre farm in 1940 (12).

The average investment in farm buildings varies only $290.00 per farm between the northeastern dairy area, eastern livestock area, and western livestock area. The northeastern dairy area has slightly the largest investment per farm due to the extensive building requirements for a successful dairy enterprise. Again in contrast to the name, dairy area, dairying is not the main enterprise. The name was given to the area only because more dairying was carried on there than in any other portion of Iowa.

In a study of size of farms in Iowa (18), it was found that they varied only a few acres between the different farming areas, and in such a matter that the figures quoted on a per-farm basis above would be affected very little. The western livestock area has the largest farm with an average of 182 acres each, and the eastern livestock area the smallest with an average of 148 acres each.

Insurance coverage on farm buildings

In a report by Gordon A. Bubolz (1), the following is stated:

> The oldest farmers' mutual windstorm company of which record has been found was incorporated in Iowa in 1884. At the end of 1935, 65 such

> companies were in existence and these had net assets exceeding $5,000,000.00 and approximately $2,740,000,000.00 of insurance in force, and about 800,000 members.

In addition to these specialized windstorm companies, there are nearly 300 farmers' mutual fire insurance companies which carry windstorm risks. The number of such companies which carry windstorm risks is small due to the nature of windstorm damage. The small companies cannot absorb the loss caused by tornadoes or widespread windstorms without covering large areas and carrying a tremendous reserve. Where fires occur one or two at a time, a windstorm may wreck the buildings of an entire locality.

The Iowa Mutual Tornado Insurance Association has become statewide and grown considerable since their first days. By 1946 their assets and emergency reserve for future losses exceeded $2,700,000.00 with $840,000,000.00 of insurance in force and about 200,000 members. Since the time the company organized they have paid over $11,420,000.00 in losses (11).

This loss figure stresses how great the economic loss has been and continues to be due to windstorm damage. The figure represents only that paid by one of many such companies and then only a portion of the total amount of wind damage in the area covered. Many buildings are not covered by insurance, and usually where a building is damaged by wind that is covered by insurance, the full amount of the actual

loss, considering all inconveniences, is not repaid in claims.

Table II gives the amount of insurance coverage on farm buildings against wind damage by the Iowa Mutual Tornado Insurance Association for the last twenty years with amount of losses paid out by this organization during that period. Figure 3 shows the trends graphically of the amount of insurance carried by this Association and the amount of wind damage averaged over a five-year period for each year. It is noted that the Association lost some of its insurance coverage during the depression of the early 30's but soon gained it back and has been gaining steadily ever since. The loss ratio reached somewhat of a peak during the depression years then dropped off some prior to the steady rise it has taken the last few years.

It is hard to realize a definite trend in the wind damage suffered. These data naturally fluctuate with the severity of the winds which very greatly from year to year and also with the cost of labor and materials. In 1946, during somewhat inflated times, the claims naturally ran higher for the same types of damage than they did during depression years. The general trend for wind damage has been upward for the last 20 years although in consideration of these data alone, it can hardly be stated that the Iowa farm buildings are becoming less wind resistant. It is possible, however, that lack of building materials, proper

Table II

WIND LOSSES AND RISK IN FORCE FOR 20-YEAR PERIOD
1927-46

Year	Risk in force	Damage	Cost per $1000 risk	Adm.Expenses per $1000	Losses per $1000 risk	5 yr. av. loss/ $1000
1927	$522,088,142	$157,274	$ .65	$ .35	$ .30	
1928	548,986,352	584,263	1.47	.41	1.06	
1929	567,370,542	220,735	.76	.37	.39	.51
1930	597,093,957	218,328	.78	.41	.37	.51
1931	607,088,266	256,502	.77	.35	.42	.43
1932	599,266,077	172,158	.58	.29	.29	.50
1933	565,098,926	400,631	1.05	.34	.71	.46
1934	552,917,162	380,785	1.09	.40	.69	.63
1935	553,644,115	106,503	.66	.47	.19	.72
1936	573,796,609	738,438	1.74	.45	1.29	.65
1937	590,641,070	448,634	1.05	.29	.76	.57
1938	612,784,837	223,251	.79	.43	.36	.59
1939	652,553,296	179,500	.73	.45	.28	.60
1940	692,617,677	162,898	.65	.41	.24	.53
1941	707,997,777	950,826	1.73	.39	1.34	.66
1942	711,746,114	289,550	.74	.33	.41	.83
1943	742,071,884	768,182	1.51	.47	1.04	.94
1944	793,195,326	894,858	1.61	.48	1.13	.76
1945	836,222,716	652,245	1.26	.48	.78	
1946	898,828,583	417,138	.94	.48	.46	
	Total	8,222,699	29.56	8.05	12.51	
	Average	411,135	1.03	.40	.63	

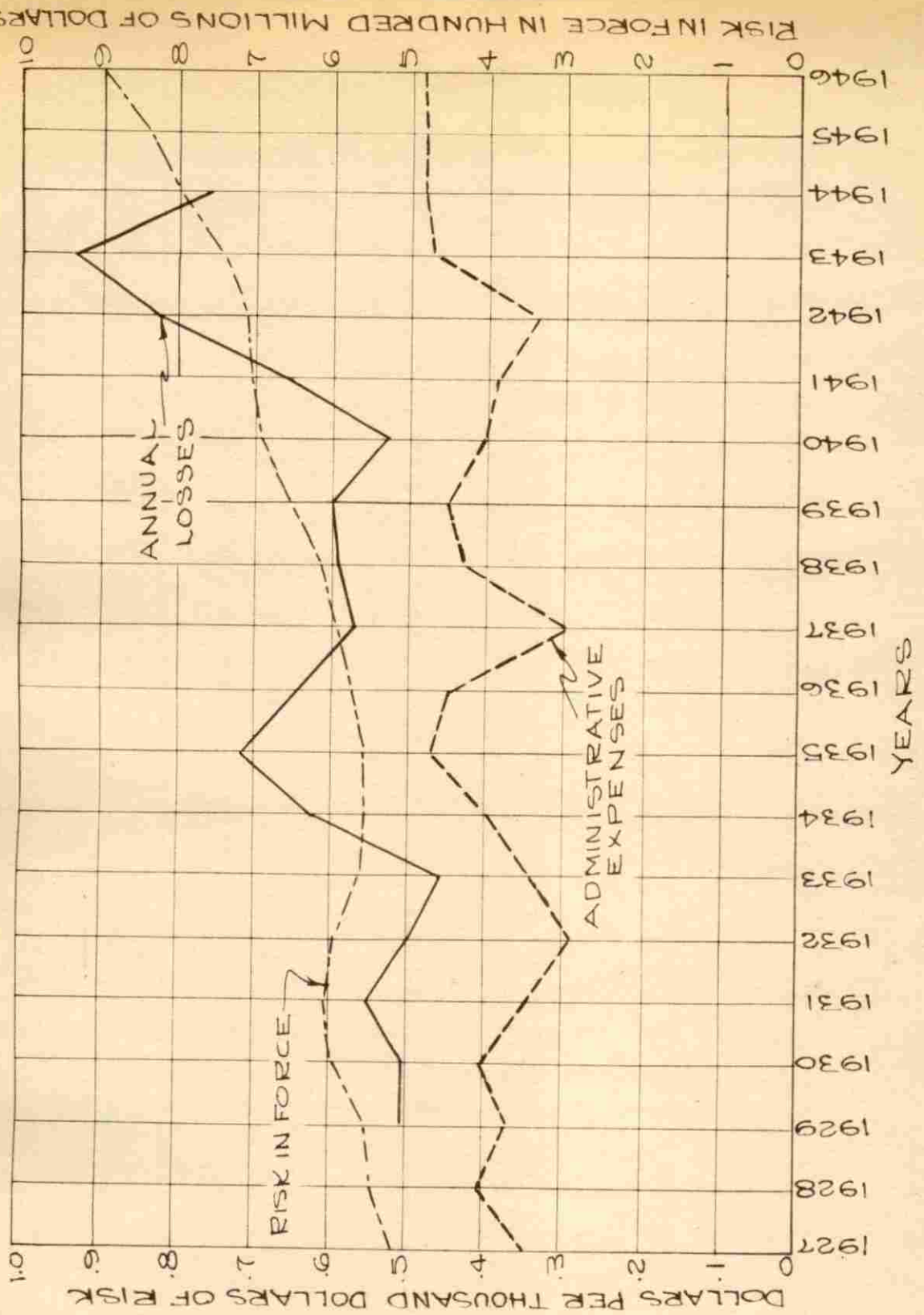

FIG. 3 TRENDS OF LOSS RATIOS AND RISK IN FORCE FOR A 20 YEAR PERIOD

repairs and labor has added some to the amount of wind damage in the last few war years. The upward trend of wind damages during the last 20 years tends to indicate that the Iowa farm buildings have been deteriorating at a faster rate than they have been rebuilt or remodeled and repaired. It is noted, though, from Figure 3 that the administrative expenses represented in dollars per thousand dollars of risk in force vary with the annual losses averaged on a five-year basis. This is logical, however, because the risk does not fluctuate from year to year like the wind damage and naturally above a certain minimum administrative expense it would vary directly as the number of claims and amount of damage.

In order to study distribution of windstorm risk, per county, carried on farm buildings by the Association, Figure 4 was prepared which represents the amount in millions of dollars per county. It is readily apparent from this figure that the counties will show an amount of coverage somewhat in proportion to their size; however, it is illustrated that the north central and northwest portions of the state carry the most wind insurance on farm buildings.

In order to obtain a more direct comparison between amount of insurance carried and amount of investment in farm buildings, the average amount of risk carried per farm from 1927 to 1946 was listed in Table I with amount of investment per farm. Figure 5 was prepared to illustrate graphically

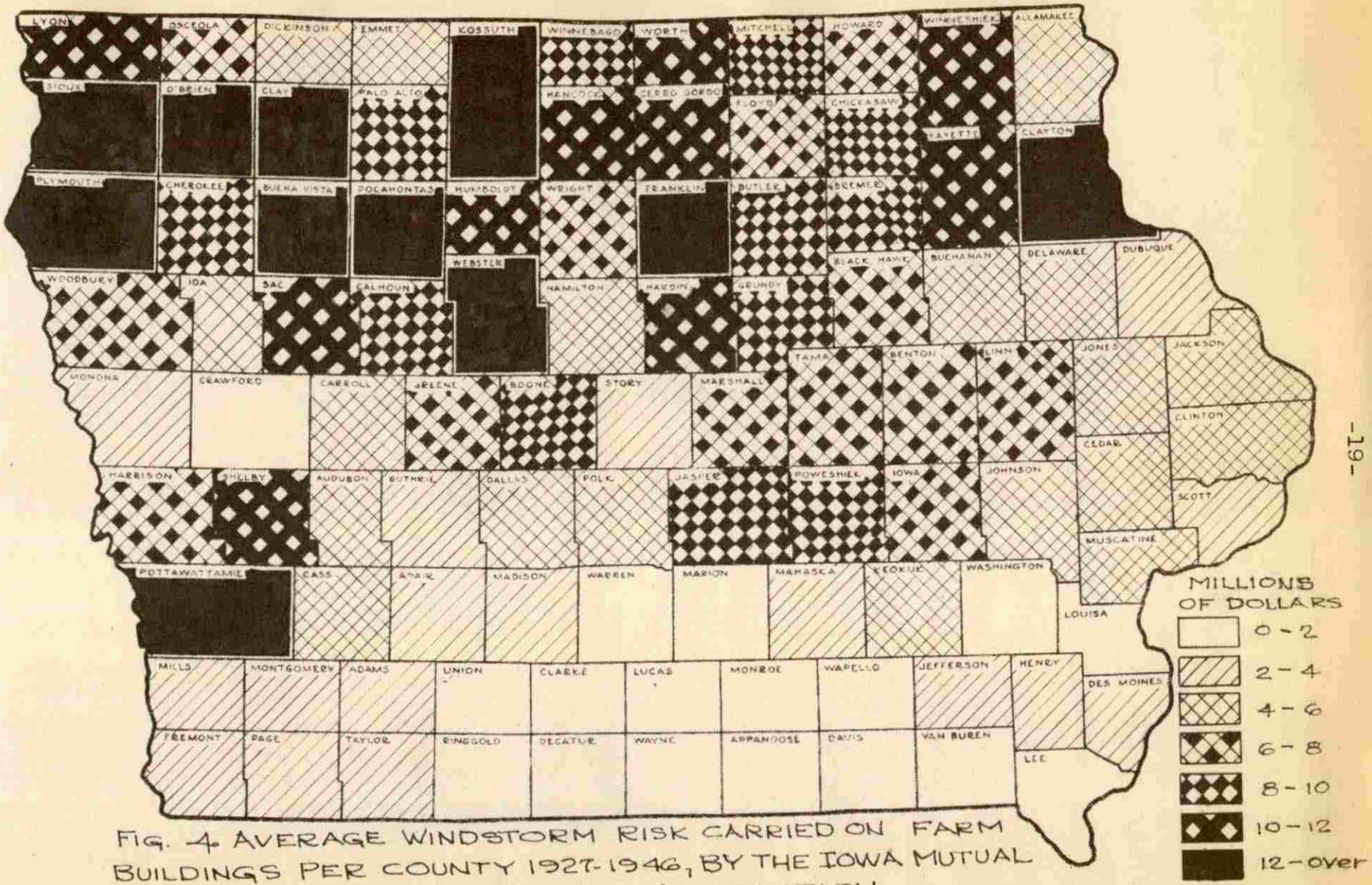

FIG. 4 AVERAGE WINDSTORM RISK CARRIED ON FARM BUILDINGS PER COUNTY 1927-1946, BY THE IOWA MUTUAL TORNADO INSURANCE ASSOCIATION

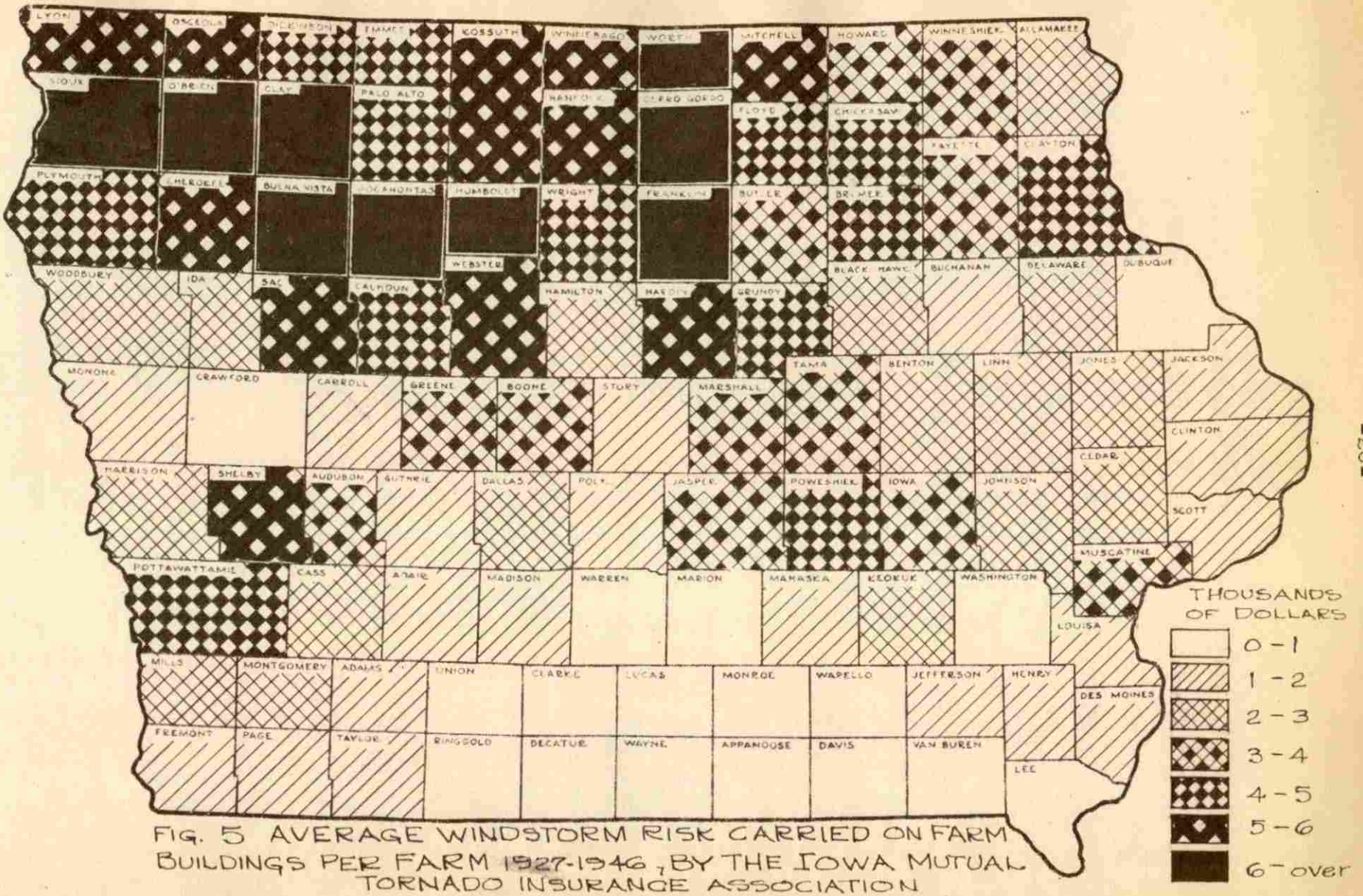

FIG. 5 AVERAGE WINDSTORM RISK CARRIED ON FARM BUILDINGS PER FARM 1927-1946, BY THE IOWA MUTUAL TORNADO INSURANCE ASSOCIATION

the insurance coverage on a farm basis. There is a definite relation between investment in farm buildings and insurance coverage in all but the east central portion of the state which shows up somewhat in contrast, with a large investment per farm but a comparatively small insurance coverage. This could be attributed to various circumstances. Perhaps the Association has not concentrated on sales promotional programs in that area as in others; or perhaps the amount of wind damage does not warrant the carrying of large amounts of wind insurance on farm buildings.

Magnitude of wind damage in Iowa

"More than 2800 tornadoes, not to mention other types of destructive windstorms, occurred in the United States during the 20-year period from 1916 to 1935." (2) This is an average of 140 tornadoes annually. In May 1930 there were 90 tornadoes, about three a day, which caused a property loss estimated at $7,000,000.00. A single storm which passed through parts of Illinois, Indiana, and Missouri in March 1925 resulted in losses amounting to approximately $16,500,000.00 (20).

Since 1884, wind losses paid for by the Iowa Mutual Tornado Insurance Association of Des Moines, Iowa, have amounted to approximately $16,500,000.00. In the last twenty years, $8,200,000.00 have been paid, with $950,000.00 being

paid in 1941 alone for the settlement of wind damage claims (11). Although this Association covers the entire state of Iowa and insures mainly farm structures, the figures quoted above are far from being representative of the total amount of wind damage to farm buildings. A few county mutuals write wind policies in Iowa from which wind damage data has not been available. Wind damage claims paid on insured property does not always cover all the losses and inconveniences suffered by the farmer and then, too, many farmers have not felt it necessary to carry wind insurance; so, consequently, an exact figure representing the total economic loss to farmers resulting from wind damage to farm buildings is difficult to arrive at. The tremendous magnitude of this loss is apparent though.

Any type of wind damage to farm buildings is an economic loss to the farm owner and operator whether he be one man or two men. The farmer is the one who must pay for all losses either directly or indirectly, depending on whether or not insurance is carried. Insurance only serves to ease the financial strain on the individual farmer who suffers a wind loss, by spreading the loss among a number of farmers.

From a study by county of wind storm damages on farm buildings, paid by the Association in Iowa for the last twenty years, no concentrated storm areas have been located. From year to year, certain counties or groups of counties

naturally have suffered heavier than others from destructive windstorms, but averaged over a period of years and tabulated on a basis of damages paid per thousand dollars of risk carried, no one area seems to have been the focal point for an excessive number of such storms.

Figure 6 illustrates the distribution of wind losses suffered by counties, tabulated as damages paid per thousand dollars of risk carried for the period of 1927 to 1946, inclusive. Counties suffering heavy losses over this period are in many cases adjoined by counties which have had exceptionally light losses. Generally speaking, a larger loss per thousand dollars of risk is shown for the northwest corner than for the southeast or for the east central portions of the state.

In averaging the losses per thousand dollars of risk carried for the different farm areas of Iowa, there was found to be only a small variance. Less than 0.20 dollars per thousand dollars of risk difference was shown, the two extremes being the dairy area with the smallest loss per thousand dollars of insurance and the cash grain area and western meat production area with the largest loss. The wind losses to farm buildings in the southern counties of Iowa appear to be about on a par with the rest of the state, although the farm building investment and risk carried are both very low as compared with other areas.

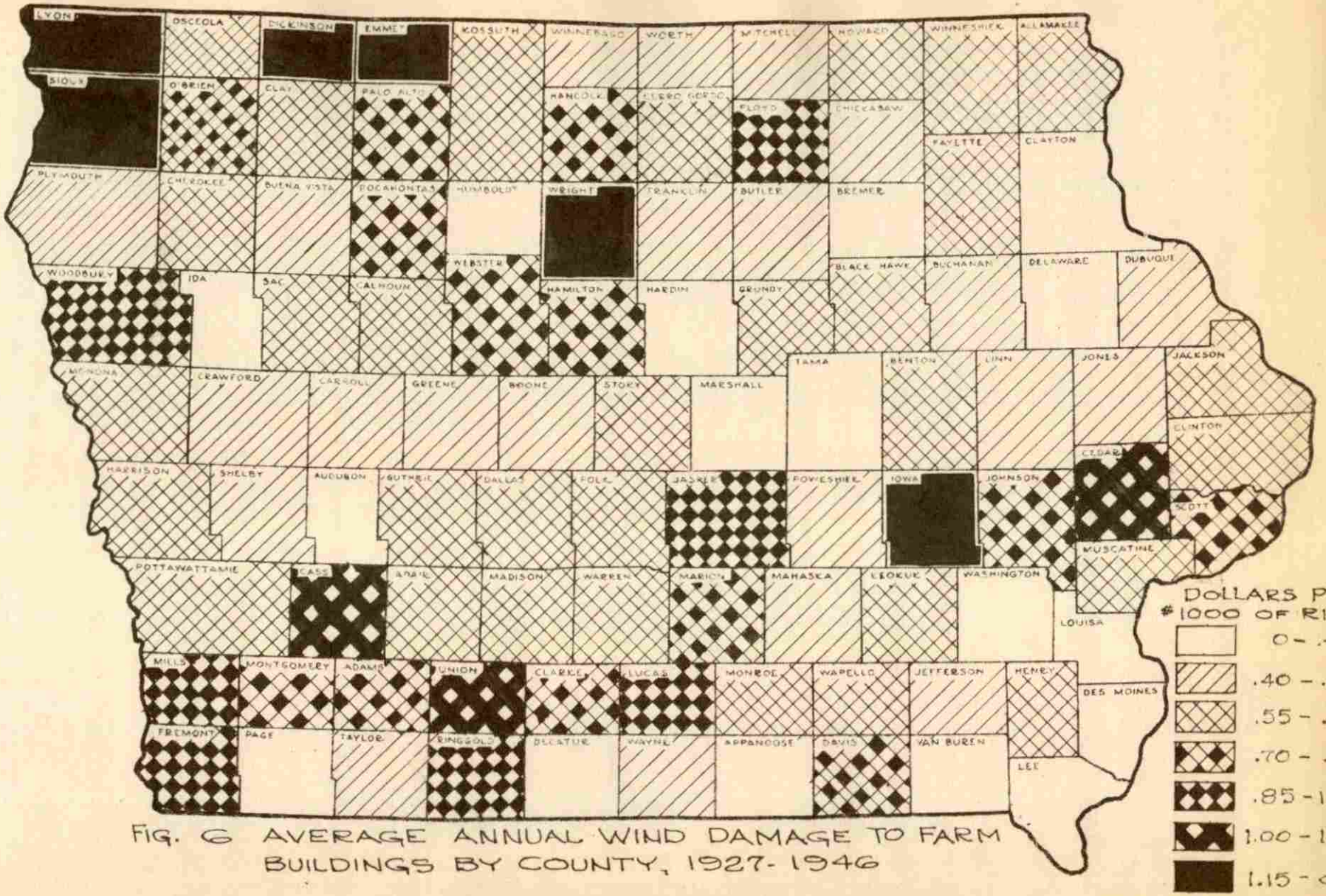

FIG. 6 AVERAGE ANNUAL WIND DAMAGE TO FARM BUILDINGS BY COUNTY, 1927-1946

The somewhat lighter losses in the northeast and east central portions of the state perhaps account in part for the small insurance coverage in that section of the state, although the building investment is as large as in any area.

Expenditure for farm building materials in Iowa

In 1939 an amount equal to 3.03 per cent of the total farm building investment was spent for building materials in Iowa (19). This included expenditures for lumber, roofing materials, hardware, cement, paint, fencing materials, and miscellaneous materials, for the maintenance of existing buildings, construction of new buildings, and for repair of buildings damaged by windstorms.

This expenditure for building materials amounted to an average of $217.00 per farm in Iowa, while only $154.00 were spent per farm in the United States as a whole. This is a 29 per cent higher expenditure per farm in Iowa for the year 1939. The only available data was for the year 1939, so whether this comparison is representative and normal cannot be verified without further information to cover a period of years.

Another interesting aspect brought out by the 1939 study was that the average amount spent by owner operators in the United States as a whole for building materials was $156.00 per farm while the amount on tenant operated farms was

$114.00 (19). This shows a 27 per cent higher average farm expenditure for building materials on the owner operated farms over the tenant operated ones.

In order to determine the distribution of the $24,114,867-.00 spent for farm building materials in Iowa during the year 1939, Table III was prepared to show the average expenditure per county and the average per farm by county. Figure 7 was prepared to show graphically the average expenditure per farm. For comparison purposes, similar breakdowns were made for the average wind damage per county for 1939, as illustrated in Figure 8, and the average value of farm buildings per farm, Figure 1, as recorded in the 1940 United States Census (18).

The distribution of wind damage to farm buildings in 1939 (Figure 8), shown in dollars per $1000.00 of risk by counties, does not compare with the average losses for the twenty-year period 1927-46 (Figure 6), the average value of farm buildings per farm taken from the 1940 United States Census (Figure 1), or with the average expenditure per farm for building materials in 1939 (Figure 7). The wind damages to farm buildings in 1939 were light as compared to the twenty-year average of 1927-46. In 1939 the average loss per $1,000.00 of risk in force was $.28 as compared to an average of $.63 for the twenty-year period.

In 1939 the heaviest wind losses were suffered in a

Table III

EXPENDITURES FOR FARM BUILDING MATERIALS
IN IOWA IN 1939

County	Farm bldg. investment in 1940	No. of farms reported	Expenditure per county	Expenditure per farm	Loss ratio 1939
Adair	$6,005,354	935	$137,435	$147	1.476
Adams	4,277,010	606	95,991	158	3.160
Allamakee	7,715,034	1,131	135,537	120	.035
Appanoose	2,814,765	752	84,251	112	.059
Audubon	6,624,020	883	161,714	184	..254
Benton	11,971,017	1,541	423,375	274	.445
Black Hawk	11,580,087	1,532	446,189	292	.185
Boone	8,704,600	1,375	363,391	264	.284
Bremer	9,856,691	1,122	198,403	177	.074
Buchanan	8,691,376	1,506	287,473	191	.236
Buena Vista	10,182,393	1,437	367,023	255	.215
Butler	9,008,177	1,320	282,999	214	.072
Calhoun	9,277,765	1,126	323,116	287	.201
Carroll	9,687,088	1,302	281,832	216	.120
Cass	7,277,513	1,191	203,185	171	1.295
Cedar	11,369,992	960	262,967	274	.168
Cerro Gordo	8,299,301	994	311,491	313	.068
Cherokee	8,398,090	913	240,421	264	.177
Chickasaw	7,681,697	1,032	183,370	178	.260
Clarke	2,667,488	615	86,056	140	.000
Clay	8,972,295	1,049	339,389	324	.079
Clayton	13,724,666	1,704	284,466	167	.081
Clinton	12,114,719	1,415	360,620	255	.214
Crawford	11,006,630	1,273	256,689	202	.152
Dallas	8,378,082	1,068	238,071	223	.309
Davis	3,487,219	742	72,267	102	.148
Decatur	3,184,010	736	94,819	129	.000
Delaware	10,510,122	1,458	271,845	186	.121
Des Moines	5,769,172	867	152,106	176	.263
Dickinson	4,625,774	754	229,568	305	.111

Continued on next page

Table III (Cont'd)

County	Farm bldg. investment in 1940	No. of farms reported	Expenditure per county	Expenditure per farm	Loss ratio 1939
Dubuque	$11,098,600	1,469	$303,011	$206	.294
Emmet	5,103,017	547	162,607	297	2.273
Fayette	11,090,589	1,951	315,842	162	.097
Floyd	3,012,589	1,085	266,996	246	.055
Franklin	9,886,454	1,144	345,804	302	.037
Fremont	5,169,668	973	205,147	211	.394
Greene	8,420,339	1,072	278,790	260	.292
Grundy	8,719,878	790	246,005	311	.181
Guthrie	6,468,419	1,291	205,900	160	.527
Hamilton	9,943,466	1,237	358,480	290	.080
Hancock	8,856,091	1,023	279,703	273	.122
Hardin	8,939,042	1,294	394,575	305	.121
Harrison	6,508,631	952	144,143	152	.112
Henry	6,348,287	868	137,776	159	.182
Howard	6,486,532	968	158,964	165	.043
Humboldt	7,242,164	883	275,827	312	.143
Ida	6,648,054	756	168,965	223	.170
Iowa	8,919,406	1,268	276,755	218	.095
Jackson	8,460,811	1,285	225,975	176	.107
Jasper	11,032,302	1,670	406,210	243	.225
Jefferson	5,158,035	904	135,574	150	.108
Johnson	11,326,544	1,432	378,683	264	.060
Jones	9,676,521	1,195	263,351	221	.430
Keokuk	7,701,312	1,374	251,589	183	.130
Kossuth	14,888,392	1,724	526,451	305	.200
Lee	5,934,381	933	160,858	173	.854
Linn	13,484,440	1,928	436,571	227	.084
Louisa	4,473,274	676	164,213	243	.433
Lucas	3,055,593	692	73,356	106	.305
Lyon	7,482,951	1,034	216,501	209	1.326
Madison	5,796,668	959	142,579	149	.466
Mahaska	8,646,070	1,386	279,145	202	.092
Marion	5,613,990	973	155,302	160	.448
Marshall	10,335,494	1,141	277,412	243	.130
Mills	4,632,931	717	165,736	231	.883

Continued on next page

Table III (Cont'd)

County	Farm bldg. investment in 1940	No. of farms reported	Expenditure per county	Expenditure per farm	Loss ratio 1939
Mitchell	$ 7,106,804	1,018	$192,864	$189	$ .064
Monona	6,145,604	930	186,216	201	.217
Monroe	2,575,150	731	71,776	98	1.379
Montgomery	5,474,058	848	143,476	169	.643
Muscatine	7,650,571	1,018	248,515	244	.056
O'Brien	10,346,390	1,291	403,656	313	.121
Osceola	5,591,165	785	232,414	296	.076
Page	7,287,227	862	144,453	168	.949
Palo Alto	7,230,252	1,041	282,594	272	.132
Plymouth	11,729,125	1,309	265,135	202	.504
Pocahontas	9,713,200	1,194	324,669	272	.077
Polk	9,758,957	1,258	292,302	233	.431
Pottawat'mie	13,396,821	1,649	357,105	217	.195
Poweshiek	8,399,508	1,165	273,838	235	.278
Ringgold	3,766,737	724	89,251	123	.217
Sac	9,424,916	1,100	288,093	262	.176
Scott	12,724,223	1,289	317,394	246	.065
Shelby	8,176,402	1,196	226,834	190	.883
Sioux	11,642,486	1,750	374,664	214	.168
Story	9,298,812	1,264	346,672	274	.088
Tama	12,088,512	1,573	368,854	235	.046
Taylor	5,283,363	988	134,974	137	1.171
Union	3,348,914	625	84,143	135	.204
Van Buren	3,459,965	795	80,979	102	.036
Wapello	4,688,600	1,022	164,699	161	.034
Warren	5,236,173	1,168	172,762	148	5.101
Washington	9,556,498	1,380	287,142	208	.022
Wayne	3,334,386	588	72,384	123	.222
Webster	10,888,573	1,462	404,006	276	.220
Winnebago	6,665,722	837	197,307	236	.228
Winneshiek	11,962,264	1,945	298,251	154	.104
Woodbury	10,237,892	1,324	250,724	190	.259
Worth	6,459,816	989	247,342	250	.039
Wright	8,803,596	1,190	325,514	273	.090
Total	794,901,864	111,241	24,114,867	213	.366

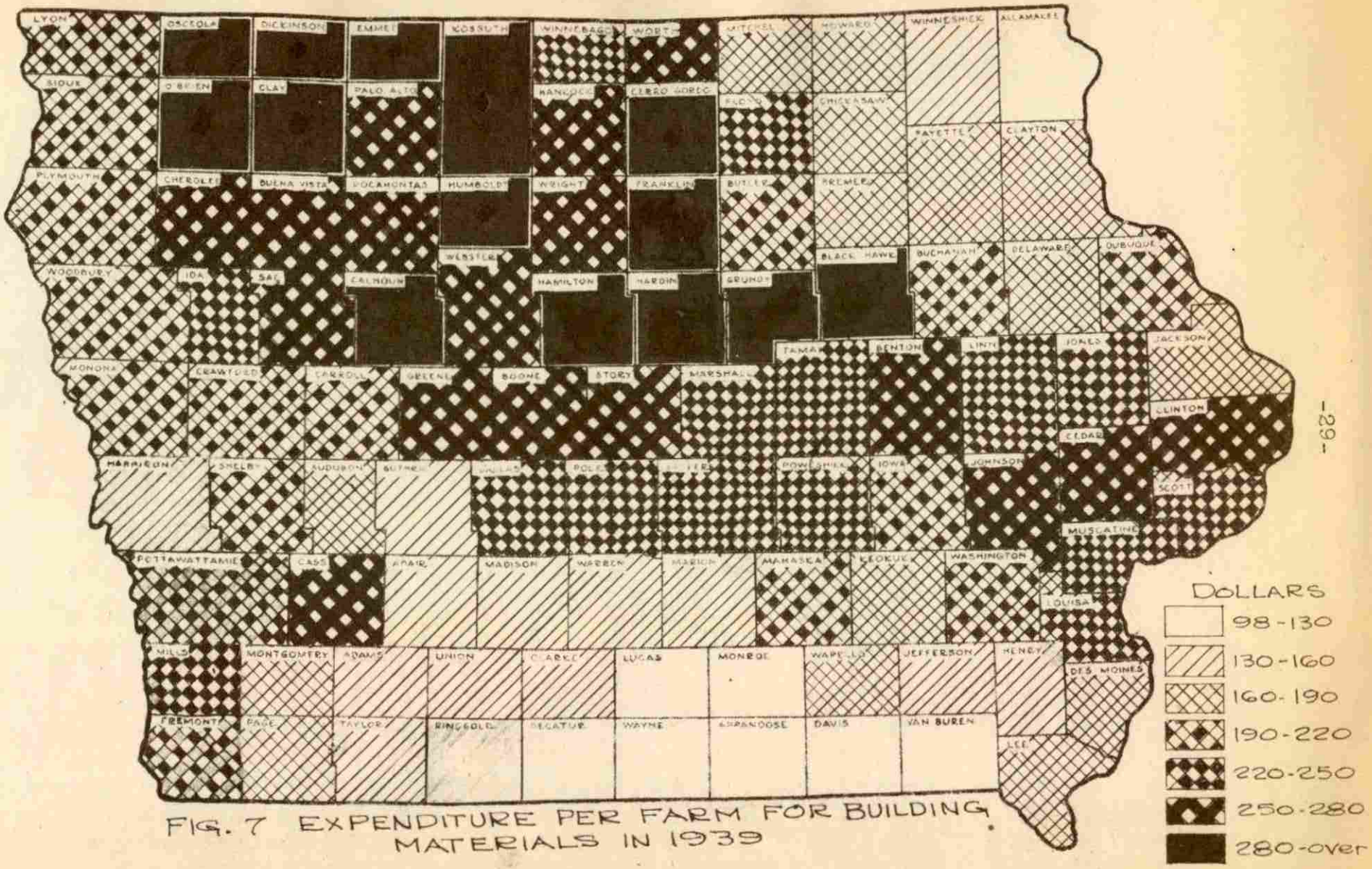

FIG. 7 EXPENDITURE PER FARM FOR BUILDING MATERIALS IN 1939

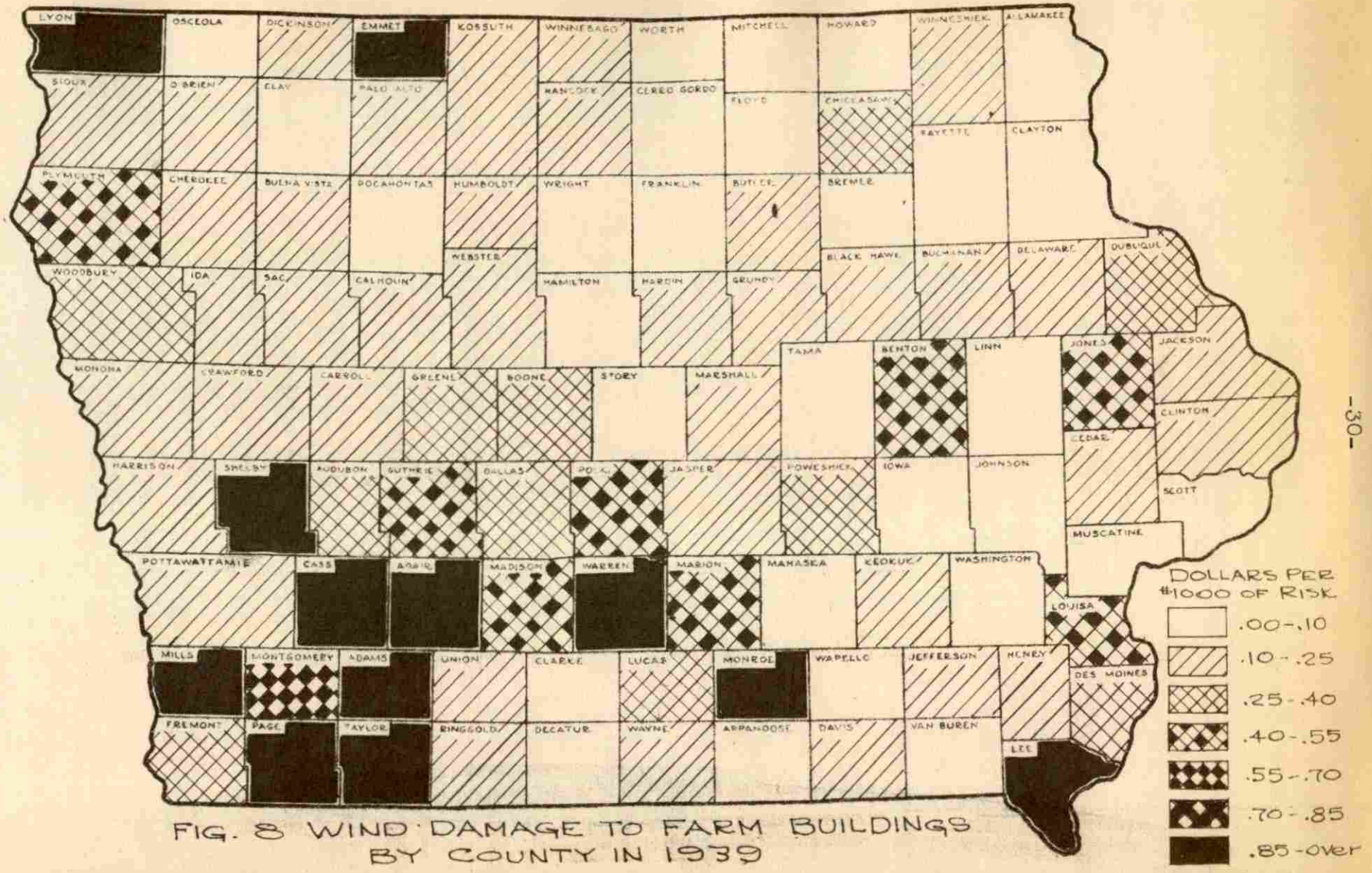

FIG. 8 WIND DAMAGE TO FARM BUILDINGS BY COUNTY IN 1939

storm area in the southwest corner of the state. In a comparison of wind losses in the various farming areas for 1939 in Figure 8 with the farm building investment as shown in Figure 1, it is brought out that the southern pasture area suffered the heaviest losses with an average of $.72 per $1,000.00 of risk in force and the northeastern dairy area the lightest with an average of $.14. In contrast, the southern pasture area has the least building investment per farm and the northeastern dairy area the most, being pretty much on a par with the eastern livestock area and cash grain area in that respect.

In a comparison of the average expenditure for farm building materials in 1939 with the average farm building investment, it is shown that the distribution of each is closely related. The southern pasture area shows the least in each case and the cash grain area, the most.

Unless there is a heavier than normal wind loss with a decidedly concentrated storm area for any one year, it is probable that the distribution of wind damages has less effect on the distribution of expenditures for farm building materials than does the distribution of the farm building investment.

REVIEW OF LITERATURE

Previous Statistical Studies

What is an economical wind resistant design for a farm building? What is an ideal risk? What are the common weaknesses in present farm building designs? These questions are typical and before improved designs can be recommended, the weaknesses must be substantiated as such. In a conference with officials of the Iowa Mutual Tornado Insurance Association, Des Moines, Iowa, October 22, 1946, Professor Henry Giese of Iowa State College stated that, recommended practices or changes in design of farm buildings must be based on facts derived from a study of cases over a period of years.

Statistical studies were made in connection with this project on the prevention of wind damage to Iowa farm buildings by Schweers (15) and Clark (3) for the period 1930 to 1933. These data are necessarily out of date to a certain extent, due to the changes in building design in the last 13 years, introduction of new building materials and methods of application, and the aging of present farm buildings which have not been maintained properly because of the depression, World War II, and at present the shortage and high cost of materials and labor.

Fenton and Otis (5) state in their bulletin entitled "The Design of Barns to Withstand Wind Loads," that, "There is an evident need for more reliable data upon which to base the design of barn frames." The most generally accepted wind pressure formulas of the past did not recognize the reduced pressures or suction on the leeward side of the buildings nor on the sides where the wind is parallel to the surface. Fenton and Otis (6) stress that the existing formulas cannot be considered adequate or reliable for the solution of wind loading on light frame buildings and state,

> Many buildings designed in the past by these methods have stood; probably because of high factors of safety or because no strong winds have struck them. Since barns constructed according to common practice have little or no factor of safety in the strength of the framing members, it is essential to know the directions and magnitude of wind pressures so that weaknesses in construction can be eliminated.

Building to Withstand Wind

There are three methods through which data pertaining to the structural weaknesses of farm buildings may be obtained; mainly, statistical studies of damage cases, observation of wind damages and by testing of models under artifically applied wind conditions.

In a report by C. K. Otis (14) pertaining to a personal observation of the destruction of a tornado which occurred

in Minnesota, September 11, 1942 and demolished 1861 farm buildings, he states,

> Reviewing the storm statistics it is noticed that only two houses were demolished by the wind. Most of the houses damaged had only minor damage unless struck by falling trees or flying debris. This tends to indicate that building a structure to withstand strong winds is not impossible. The easy way out is to say no structure could withstand a wind like that and then rebuild the structure incorporating the old weaknesses.
>
> If one outstanding factor is to be named that would cover most of the failures observed, it would be joints.

In reference to a report on the St. Louis tornado of 1896 which damaged 7,000 buildings, Robins Fleming (7) says,

> The wind velocity near the center of the tornado probably reaches 400 to 500 miles per hour over a small area and it is not to be expected that any economical construction can withstand the force which will result. On the other hand, there seems to exist on either side of the tornado vertex a strip of varying width which is subjected to a direct wind pressure of high intensity, but not too great to be met by economical construction. This effect is plainly observed when making a study of a tornado path. It would seem that in this particular area the damage might be reduced to less than one-fourth if buildings were properly constructed to withstand pressure ordinarily specified in a building code.

The above observations tend to indicate that an attempt to lower damage, through better designs, resulting from the worst of windstorms, the tornado, need not be fruitless.

Giese (10) states,

> In general, two types of storms cause damage to buildings. The first is the tornado, a very rapid whirl of small diameter; the second is the cyclone or hurricane, which is of such large diameter that it appears to be a straight wind.

Generally speaking, tornadoes are infrequent in Iowa and usually cover only small areas, which high velocity winds of a cyclonic nature are common and consequently cause a majority of the wind damage.

Weaknesses in Present Design of Iowa Farm Buildings

Curry (4) states in a study of farm buildings that,

> Structural defects observed were so numerous and varied that no complete classification will be attempted. Some defects occurred so frequently and others so obvious that they are mentioned. Despite the rather common close spacing of posts, conditions of the girders indicated that in nearly all cases the main floor joist system was capable of transmitting a far greater load to the girders than those girders could safely carry. Even in the mow floor, using 2" x 6" joists, the girders showed more evidence of overload than did the floor joists. Free standing posts, 2" x 6" and 2" x 8", or wind bracing members exceeding 16 feet in length, were observed in two cases. No real structural support was afforded by these members.

Giese (9), in reference to common structural weaknesses in farm buildings, says,

> In most wood construction, the weakest places are the joints. The proper fastening of members requires careful workmanship and often the strength of beam is materially lessened because of ineffective fastenings. All joints

> should be well nailed or bolted with due care to avoid splitting. A nail is not very effective at best and may be nearly worthless if it is driven so as to split the wood.

In a paper on designing farm buildings for wind resistance, Giese (8) stresses further the importance of good joints by stating,

> Particular care must be taken at the joints. Nails although easy to use because of the ease of driving, are comparatively ineffective. It is physically impossible to drive a sufficient number of nails into the end of a structural member to make the joint comparable in strength to the timber as a beam or as a brace. Where splitting occurs, what little strength the nail joint had disappears. A few well placed bolts will return very satisfactory dividends but still better results can be attained by the use of timber connectors.

The above quotations indicate that there are numerous common weaknesses in farm buildings that through proper design can be eliminated. It is believed by the author that for most effective results in the prevention of wind damage to Iowa farm buildings, a continued statistical study of all wind damage cases over a period of years is required. These factual data would show the trends of types of building failures resulting from wind.

INVESTIGATION

Method of Procedure

Scope of survey

The survey consists of a study of all windstorm claims paid by the Iowa Mutual Tornado Insurance Association for 1946. This Association carries about nine-hundred million dollars of windstorm risk on farm buildings in Iowa and a few adjoining counties of South Dakota. The total windstorm damage settlement paid by the Association in 1946 amounted to $389,867,000 for 10,078 windstorm damages.

For each of the 10,078 damages of 1946 the following data were obtained: type of damage or building failure, amount of loss, type of building, age of building, type of roofing, age of roofing, amount of building, policy, and class A insurance, cause of loss, number of buildings damaged, location as to county, and date of loss.

The procedure was developed for the collection of wind loss data from the Association's records for a period of years. It is hoped that valuable information may then be obtained as to various trends in wind damage to farm buildings in Iowa. The initial study of 1946 is intended to produce a workable procedure for the compilation of data for

continued surveys, and to analyze windstorm losses to farm buildings as to type of loss and cause of failure.

Source of data

For each wind damage suffered under any policy written and carried in good standing by the Iowa Mutual Tornado Insurance Association, a loss report and a proof of loss is completed. The proof of loss was the main source of information for the survey, although they were in many cases not filled out completely. The adjustors are relied upon to fill out the proofs of loss and in many cases they did not distinguish definitely as to the cause, type or amount of loss. Two or three types of damage on various buildings were in many cases reported on the same proof of loss, and the amount of loss was not always segregated to an extent that a certain portion could be recorded for each type of damage.

The process of extracting the data from the Association's records proved to be very time consuming and also inaccurate to a certain extent, because the missing data were supplied by the recorder. Rather than put down a zero for unknown figures, an average figure was supplied in order that the final tabulations be as accurate as possible.

Following the recording of the data from the proof records onto forms by the use of a numerical code, the data were then transferred to hollerith cards from which accurate

tabulations were made with I.B.M. machines.

Special Objectives

The specific objectives of this investigation are:

1. To develop a procedure for the recording, tabulating and analyzing of wind data for a contemplated study of ten years or more.

2. To complete an initial survey with the above procedure for 1946.

3. To analyze the 1946 wind data as to type, cause, and amount of loss; magnitude of claims; and age of buildings and roofing when damaged.

4. To bring up to date any similar data which may, because of wind damage trends, be inaccurate or non-representative of present-day losses.

5. To analyze in detail wind damage to roofing material on farm buildings.

6. To determine the probability of wind damage to asphalt shingles over that of wood.

7. To analyze specifically the damage to concrete block buildings as pertains to wall failures and roofs coming off at the plate.

8. To analyze insurance coverage with a view of determining what classes of buildings are the best and which the poorest risks.

9. To bring to light the most prevalent types of wind damage to farm structures; and to determine how such failures may be eliminated or lessened in magnitude, which would ultimately mean an economic saving to the farmer and cheaper wind insurance on these preferred risks.

RESULTS AND FINDINGS

Distribution of Wind Damage in Iowa During 1946

Wind damage to Iowa buildings during 1946 was quite dispersed throughout the state. As illustrated by Figure 9 in dollars per thousand dollars of insurance in force, there appears to be one concentration of counties suffering heavy wind damage in the south central portion of the state. From Table IV it is noted that the damage in dollars in the southern area was small in comparison to some of the north central and northweat counties. The total damage in none of the southern counties exceeded $5,000.00, while for Kossuth county in the north central part of Iowa the damage was $51,207.00.

Regardless of the magnitude of damages paid by the Association in the various counties, the darkened area in the south central portion of the state in Figure 9 is an indication that there was severe damages there by wind during 1946. The small magnitude of damage is accounted for by the fact that only a small amount of risk is carried by the Association in the southern counties as indicated by Column 1 of Table IV. The farm building investment is also low in this area, as indicated by data given in Column 1 of Table I.

Table IV

DISTRIBUTION OF WIND DAMAGE BY COUNTIES IN 1946

County	Risk in force	No.of losses	No.of loss cases	Amt. of damage	Building insurance	Loss/ $1000 risk
Adair	$5,060,546	47	39	$1,328	$ 70,425	$.263
Adams	3,386,377	62	53	1,142	101,530	.338
Allamakee	6,821,795	34	28	693	43,025	.101
Appanoose	976,450	36	29	1,031	39,190	1.050
Audubon	8,586,926	92	66	2,285	91,450	.267
Benton	8,535,461	31	23	1,206	54,250	.142
Black Hawk	8,204,944	68	61	1,695	114,050	.207
Boone	10,751,445	88	65	2,789	148,615	.260
Bremer	9,418,650	67	48	2,413	92,875	.256
Buchanan	4,892,010	20	17	496	26,300	.102
Buena Vista	19,145,258	301	209	15,051	385,105	.786
Butler	11,362,012	61	47	1,512	89,870	.133
Calhoun	9,953,171	120	109	2,609	214,160	.262
Carroll	5,707,022	43	40	1,166	82,325	.205
Cass	6,550,824	44	41	783	51,400	.119
Cedar	7,200,664	34	25	1,259	46,590	.175
Cerro Gordo	15,552,507	88	69	3,508	132,865	.226
Cherokee	13,407,244	124	85	5,804	126,860	.432
Chickasaw	10,327,941	210	142	7,404	226,675	.716
Clarke	440,430	86	34	4,128	108,035	9.400
Clay	20,588,930	154	137	6,187	225,950	.301
Clayton	15,268,331	37	34	903	65,500	.059
Clinton	6,099,440	21	19	722	36,125	.118
Crawford	952,325	10	8	303	11,550	.316
Dallas	8,987,640	224	144	7,314	283,535	.813
Davis	191,195	3	2	811	1,400	4.260
Decatur	667,410	18	8	941	25,950	1.405
Delaware	7,388,410	42	31	1,347	79,130	.183
Des Moines	3,790,600	37	32	1,267	59,400	.335
Dickinson	10,097,631	70	60	2,600	81,175	.257
Dubuque	2,877,730	14	12	385	32,000	.135
Emmet	9,109,653	155	105	4,807	183,645	.528
Fayette	13,269,239	48	40	979	72,200	.074
Floyd	9,920,606	101	71	5,843	131,225	.589
Franklin	18,638,040	101	84	2,501	150,075	.134

Continued on next page

Table IV (Cont'd)

County	Risk in force	No.of losses	No.of loss cases	Amt. of damage	Building insurance	Loss/ $1000 risk
Fremont	$2,644,202	36	29	$1,258	$47,850	$.478
Greene	11,539,187	109	93	2,044	158,440	.177
Grundy	12,919,240	93	82	2,623	157,950	.203
Guthrie	5,730,228	80	65	2,987	117,975	.522
Hamilton	7,522,104	60	53	1,511	111,950	.201
Hancock	17,355,312	239	164	8,720	326,050	.503
Hardin	8,209,300	99	81	2,122	148,500	.144
Harrison	14,669,415	483	198	18,657	674,100	2.275
Henry	8,129,738	23	21	953	31,800	.277
Howard	3,430,216	120	84	6,457	140,850	.795
Humboldt	13,815,301	127	97	6,530	137,635	.472
Ida	5,626,498	26	22	850	50,350	.151
Iowa	7,905,063	48	40	1,751	63,925	.221
Jackson	6,444,167	101	74	2,576	162,550	.401
Jasper	13,456,555	226	159	4,487	411,395	.334
Jefferson	3,758,610	85	52	5,791	116,775	1.540
Johnson	7,463,578	61	41	2,970	93,725	.398
Jones	6,807,524	34	31	3,020	57,450	.444
Keokuk	7,137,748	130	83	3,653	169,475	.511
Kossuth	23,609,932	774	450	51,207	946,780	2.167
Lee	1,419,600	12	12	587	19,450	.416
Linn	9,177,469	32	26	768	39,650	.084
Louisa	2,434,025	19	13	1,640	33,850	.675
Lucas	2,430,185	67	47	1,661	73,850	.684
Lyon	16,387,369	193	136	13,543	246,300	.828
Madison	5,864,070	93	73	2,409	132,600	.411
Mahaska	4,035,154	121	70	3,567	150,375	.884
Marion	2,960,894	145	100	4,338	214,025	1.467
Marshall	10,696,566	57	44	1,261	103,300	.118
Mills	5,439,436	31	22	1,121	37,520	.206
Mitchell	12,593,923	58	51	3,063	99,600	.243
Monona	5,584,284	71	45	2,051	84,105	.367
Monroe	117,275	6	4	577	7,250	4.830
Montgomery	8,212,462	22	20	664	32,325	.080
Muscatine	7,180,015	39	35	1,529	60,801	.213

Continued on next page

Table IV (Cont'd)

County	Risk in force	No.of losses	No.of loss cases	Amt. of damage	Building insurance	Loss/ $1000 risk
O'Brien	$26,356,610	188	165	$7,617	$312,850	$.289
Osceola	10,475,117	171	134	6,915	198,990	.468
Page	4,891,134	62	56	3,421	90,200	.700
Palo Alto	13,185,382	159	126	4,200	200,140	.319
Plymouth	18,544,276	129	92	3,461	179,250	.187
Pocahontas	17,494,574	400	308	18,520	684,977	1.060
Polk	6,584,741	83	69	1,804	156,425	.274
Pottawat'mie	22,547,371	322	212	10,798	535,500	.479
Poweshiek	12,523,003	89	75	4,228	138,000	.338
Ringgold	1,835,353	37	27	631	35,550	.342
Sac	16,613,631	157	122	4,180	320,655	.252
Scott	3,468,519	12	11	165	21,000	.049
Shelby	12,993,433	112	88	3,635	167,895	.281
Sioux	25,957,704	441	293	15,867	609,980	.612
Story	4,352,423	39	34	1,134	74,430	.260
Tama	10,161,599	106	86	1,630	151,280	.161
Taylor	3,814,670	53	51	1,039	60,750	.273
Union	1,030,253	65	43	4,720	106,735	4.585
Van Buren	2,004,020	20	19	427	24,550	.215
Wapello	1,075,490	8	8	593	14,200	.546
Warren	3,237,232	86	61	3,019	134,050	.933
Washington	1,319,450	12	10	153	28,500	.114
Wayne	1,777,974	93	54	3,076	88,600	1.730
Webster	18,636,417	157	143	4,126	274,325	.222
Winnebago	13,784,631	82	66	3,667	101,355	.267
Winneshiek	14,573,381	143	91	4,795	202,275	.329
Woodbury	5,851,553	57	45	2,352	98,700	.402
Worth	14,136,897	79	61	6,141	129,400	.434
Wright	13,283,655	105	87	3,395	164,350	.256
Total	879,345,997	10,078	7,271	389,867	4,449,893	.512

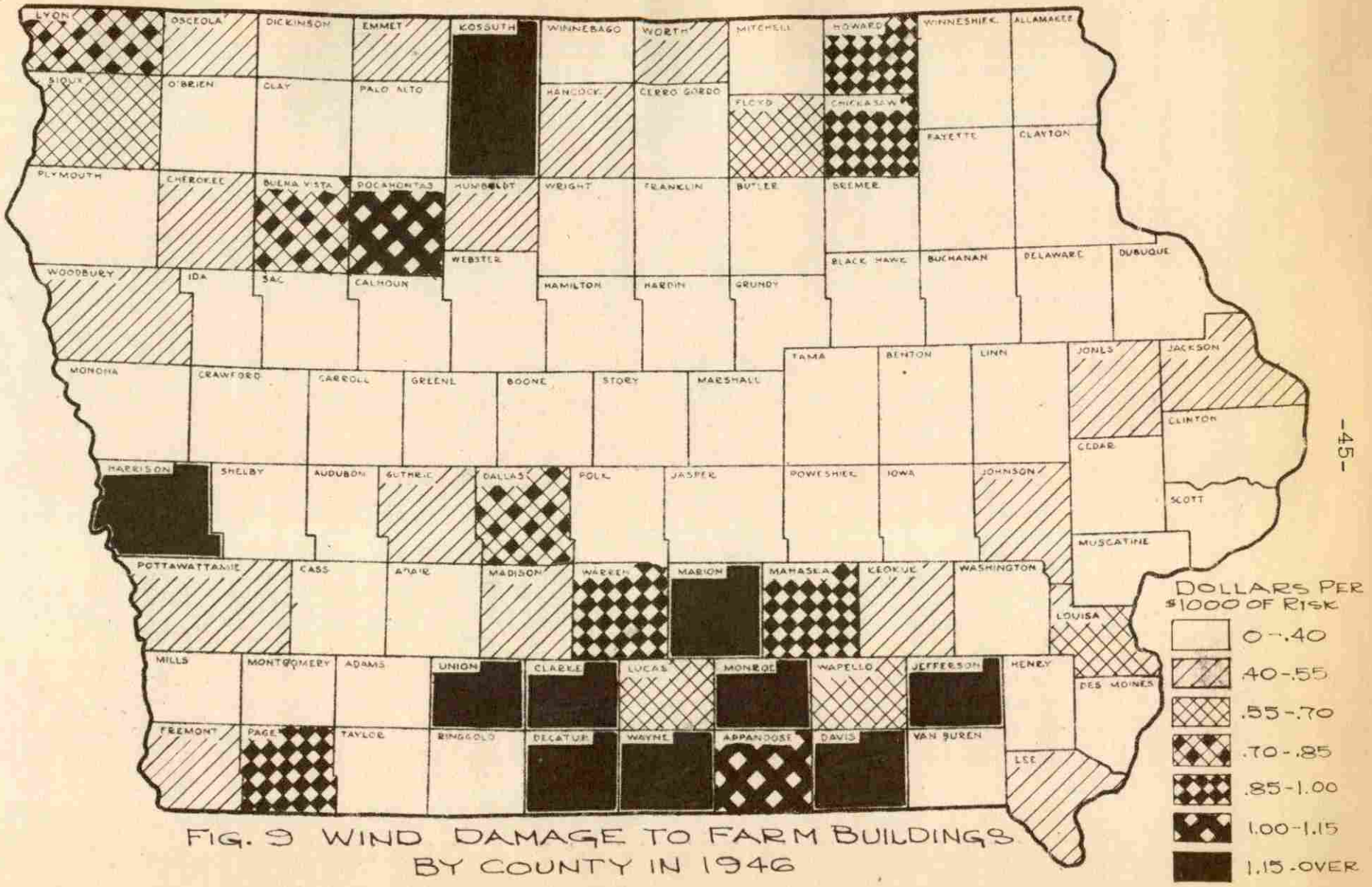

FIG. 9 WIND DAMAGE TO FARM BUILDINGS BY COUNTY IN 1946

The large amount of wind damages in Kossuth County is accounted for partly by the fact the county is about twice as large as the average in Iowa and there is a large amount of risk carried on the farm buildings there, as indicated by Table IV. Also, the investment in farm buildings is large there, averaging nearly $5,000.00 per farm in 1940, as indicated by Column 3 of Table I. The wind damage in the county for 1946, however, was heavy along with a more than average amount of hail damage which added appreciably to the magnitude of loss.

Harrison County in the west central portion of the state suffered heavy losses, as indicated by Figure 9, and is nearly surrounded by counties having a comparatively light wind loss. Again this is due partly because the county is larger than average, but mostly it is a result of a concentrated hail storm which hit mostly in that county with some lap over into Pottawattamie County. Over $10,000.00 of the $18,000.00 total damage in Harrison County for 1946 was recorded as hail damage, as shown in Table XVII.

There appears to be very little if any comparison between the distribution of wind damage in Iowa in 1946 as represented by Figure 9 and the average annual wind damage for the twenty-year period 1927-46 as represented by Figure 6.

Wind Damage by all Causes

Type of damage

First to be considered in this study of wind damage to Iowa farm buildings was the analysis of losses by type of damage resulting from all causes. The "causes" are classified as direct and indirect. The direct causes are wind and hail, and the indirect ones, which cause damage due to wind acting in an indirect way, are falling trees, flying debris, falling silos and windmills, and water.

The magnitude of loss and number of loss claims from all causes for each of the fourteen major types of building failures were tabulated for each type of farm building and listed accordingly in Table V. These data are represented graphically in Figure 10. This tabulation represents $354,454.00 of damage and 8,936 claims, which was the damage in 1946 to Iowa farm structures underwritten by the Iowa Mutual Tornado Insurance Association.

Of the twelve major types of damages represented in Figure 10, demolition of buildings with 33.7 per cent of the total has the greatest magnitude of loss. In contrast to the damage by demolition of buildings, the number of damages accounted for only 3.5 per cent of the total number; indicating that the damages were much larger than other types.

Table V

DAMAGE TO IOWA FARM BUILDINGS BY ALL CAUSES IN 1946

		Barn	Crib	Dwelling	Hog house	Mach. house	Poult. house	Misc. bldg.	Total
Demolished	D:	72,504	14035	1,200	10886	9,279	7,181	4,070	119155
	N:	92	47	1	42	43	50	37	312
Roofing	D:	17,054	5208	39744	2807	1,838	2,486	4,279	73416
	N:	677	251	1531	117	85	131	178	2970
Out of plumb	D:	30,146	4468	651	2000	2,113	894	854	41126
	N:	327	84	7	48	66	27	43	602
Doors	D:	10,982	7898	2932	83	803	66	837	23601
	N:	604	466	258	6	60	11	66	1471
Misc. Damage	D:	1,743	1159	4008	532	117	510	1393	9462
	N:	93	40	149	26	12	22	34	376
Off foundation	D:	9,260	2787	60	1387	1,787	1,948	910	18139
	N:	73	55	1	36	35	67	38	305
Glass	D:	1,359	0	10199	1035	0	949	2,167	15709
	N:	170	0	1052	126	0	144	74	1566
Roof off	D:	9,063	1798	369	1366	1,829	744	528	15697
	N:	113	44	21	18	22	20	14	252
End or side out	D:	8,348	993	0	1498	952	967	358	13116
	N:	103	16	0	22	20	25	13	199
Paint damaged	D:	2,063	686	6482	146	73	145	91	9686
	N:	81	39	210	15	7	13	10	375
Addition	D:	4,297	0	1033	0	0	0	0	5330
	N:	43	0	12	0	0	0	0	55
Cupola	D:	4,256	492	0	0	0	0	0	4748
	N:	186	29	0	0	0	0	0	215
Chimney	D:	0	0	2875	0	0	0	0	2875
	N:	0	0	146	0	0	0	0	146

Continued on next page

Table V (Cont'd)

		Barn	Crib	Dwelling	Hog house	Mach. house	Poult. house	Misc. bldg.	Total
Porch	D:	0:	0:	2394:	0:	0:	0:	0:	2394
	N:	0:	0:	92:	0:	0:	0:	0:	92
Total	D:	171075:	39524:	71947:	21740:	18791:	15890:	15487:	354454
	N:	2562:	1071:	3480:	456:	350:	510:	507:	8936

Second in importance in considering economic loss due to wind is damage to roofing material which accounted for 20.7 per cent of the damage and 33.3 per cent of the buildings damaged. In number of buildings damaged, roofing losses headed the list of the twelve items of damage. This means that one out of every three damage claims received by the Association for wind losses to Iowa farm buildings in 1946 was for a damaged roof. This classification includes all types of roofing material except roll roofing which the Association does not insure.

Buildings being blown out of plumb caused 11.6 per cent of the total wind damage to farm structures, which placed it third in importance in the consideration of economic loss.

Damage to doors and windows accounted for a large per cent of the damage claims, but a comparatively small amount of the damage. Both items are comparatively small and numerous throughout the farm buildings. If either a door or window are damaged to the extent that it must be replaced, the cost does not run very high, although the total for all of them damaged is significant.

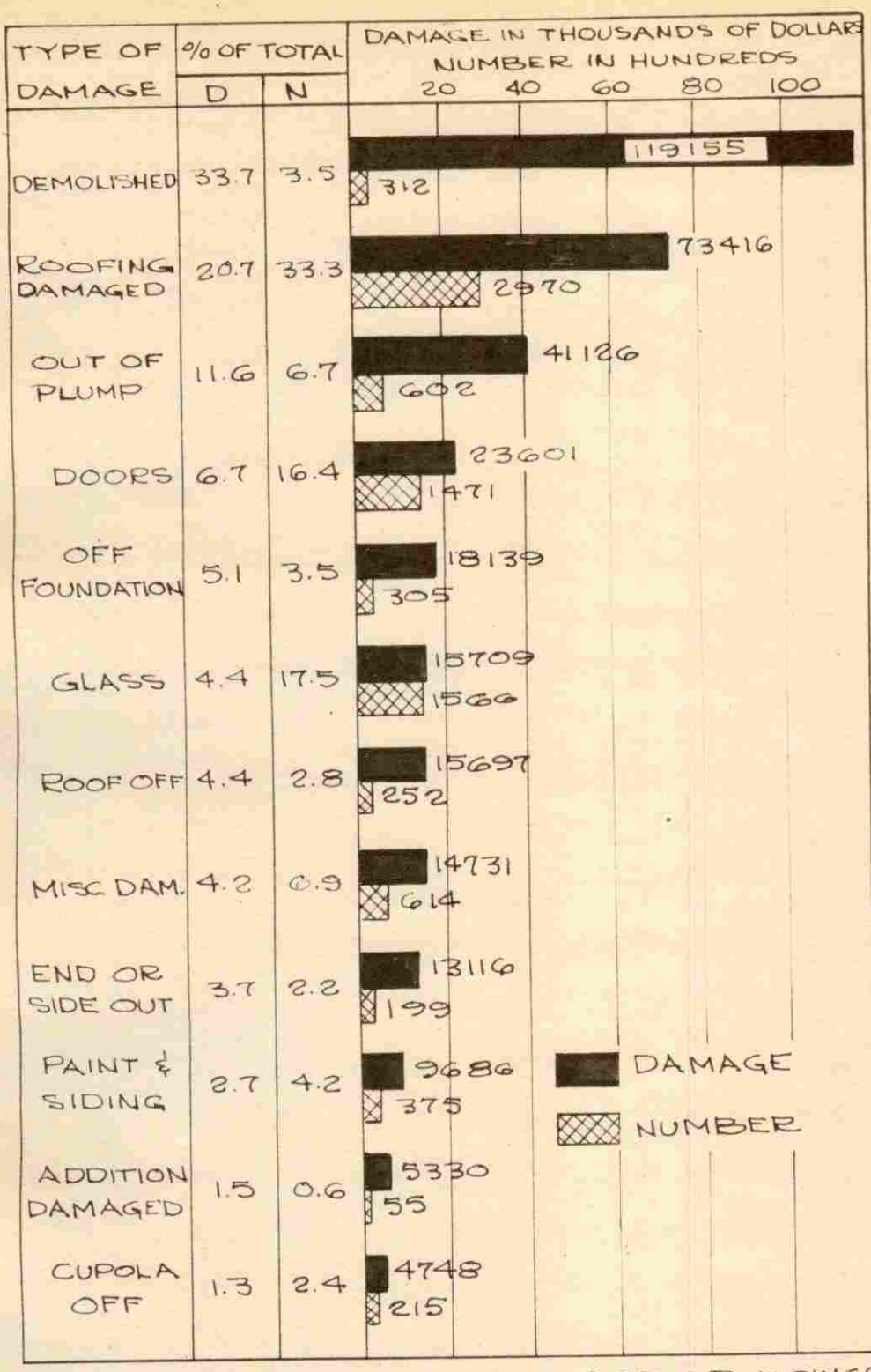

FIG. 10 DAMAGE TO IOWA FARM BUILDINGS BY ALL CAUSES IN 1946

Damage by type of property

To determine what amount of wind damage was suffered by property other than farm buildings, Table VI was prepared which lists the magnitude of loss and number of damages for each item by cause. Figure 11 shows graphically the amount and per cent of total loss for each type of property for which wind damage was paid by the Association in 1946.

The barn suffered 43.6 per cent of the damage which was over twice as much as any other building or class of farm property. One-fourth of the claims pertained to wind damage to barns. Next in magnitude of loss was the farm dwelling which accounted for 18.4 per cent of the loss and 34.5 per cent of the damages. The per cent of claims was higher than the per cent of damage by a significant margin, which indicates that the type of damage to the dwellings was more of a minor nature involving less money than the damage to barns or other farm buildings.

Wind damage to property other than to farm buildings amounted to 11.1 per cent of the number of damages. Damage to farm machinery was the item accounting for a large per cent of the losses other than to buildings. Machinery damage accounted for 9.1 per cent of all the claims and 6.4 per cent of the total damage. The types of machinery damaged most frequently were hay racks, wagons, hay loaders, and grain

Table VI

WIND DAMAGE TO IOWA FARM PROPERTY
OTHER THAN BUILDINGS IN 1946

		Wind	Hail	Rain	Debris	Trees	Other	Total
Feed	D:	416:	180:	1,272:	184:	:	:	2,052
	N:	10:	2:	25:	4:	:	:	41
Livestock and poultry	D:	554:	242:	36:	7,232:	693:	:	8,757
	N:	11:	10:	1:	120:	13:	:	155
Elevators	D:	7,188:	:	:	174:	304:	:	7,666
	N:	220:	:	:	3:	7:	:	230
Hay loaders	D:	1,006:	:	:	85:	121:	:	1,212
	N:	44:	:	:	3:	4:	:	51
Racks and wagons	D:	7,077:	:	:	15:	649:	:	7,741
	N:	396:	:	:	1:	26:	:	423
Other machinery	D:	3,141:	20:	:	2,959:	2,229:	15 :	8,364
	N:	83:	1:	:	72:	57:	1 :	214
Misc. items	D:	170:	:	:	117:	70:	:	357
	N:	5:	:	:	8:	3:	:	16
Total	D:	19,552:	442:	1,308:	10,766:	4,066:	15 :	36,149
	N:	769:	13:	26:	211:	110:	1 :	1,130

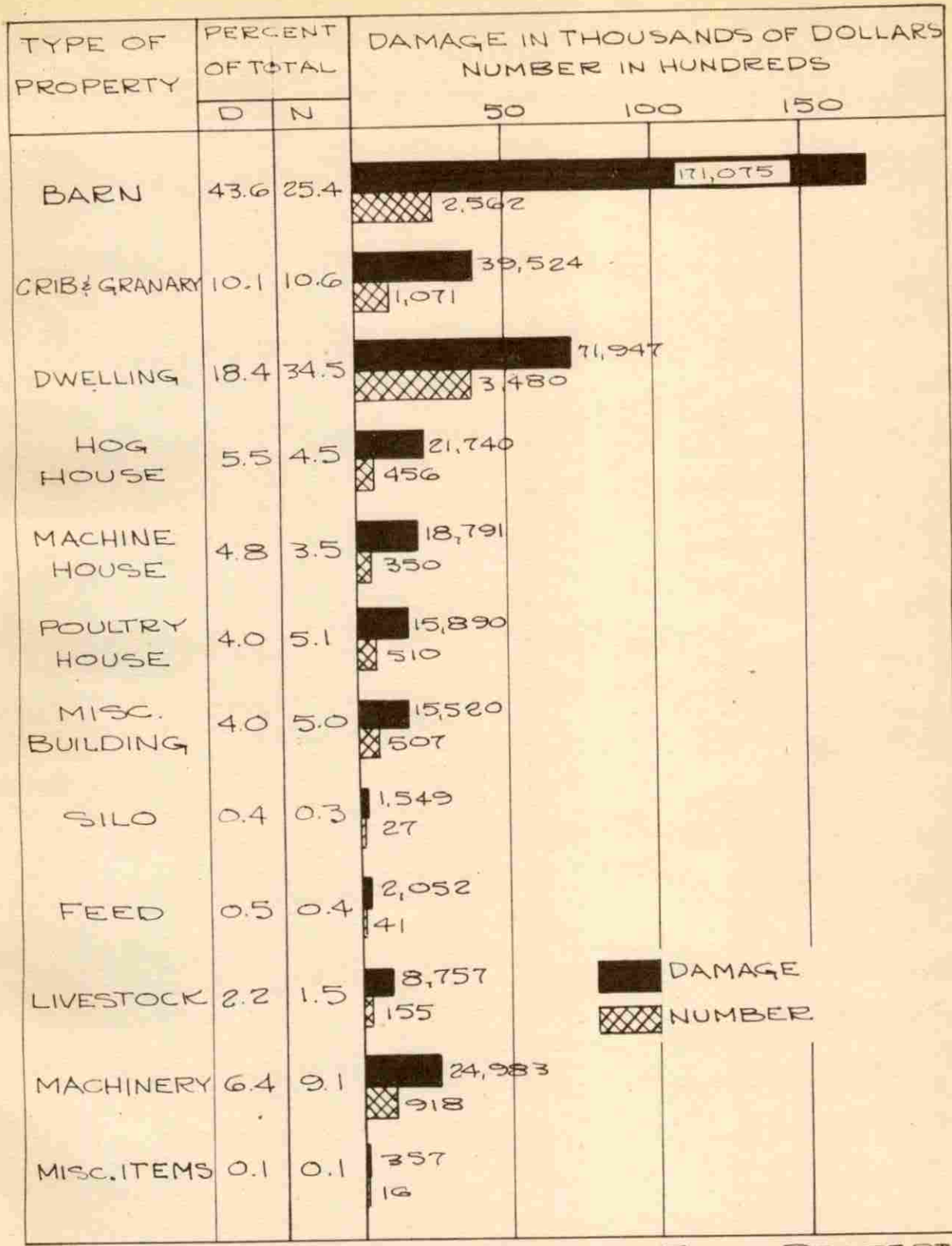

FIG. 11 WIND DAMAGE TO IOWA FARM PROPERTY BY ALL CAUSES IN 1946

elevators. The racks and wagon boxes were blown off or over on their sides in most cases. Damage to the grain elevators was usually a result of them blowing from the corn crib or building which they were on.

Damage to feed was usually an indirect cause of wind, generally from water after a wind-damaged building allowed rain to enter.

Damage to livestock which included poultry, was usually from flying debris or the collapsing of a building which they were in.

Miscellaneous items included such items as feed bunks and other items of equipment for which no classification was set up.

Causes of damage

In an analysis of the cause of damage to farm buildings, Tables VII, VIII, IX, X, and XI were prepared, one for each of the major causes of damage; namely, wind, hail, falling trees, flying debris, and other causes. Each table has the amount of damage and number of damages segregated for each type of building and by type of damage. The data is represented graphically in Figure 12 by cause of loss, giving also per cent of total loss for each cause. It is noted from Figure 12 that 83.4 per cent of the damage was due directly to wind, and that 73.5 per cent of the damages were a result

Table VII

DAMAGE TO IOWA FARM BUILDINGS CAUSED DIRECTLY BY WIND IN 1946

		Barn	Crib	Dwelling	Hog house	Mach. house	Poult. house	Misc. bldg.	Total
Demolished	D:	71,313	13710	1200	10786	9279	6550	3960	116798
	N:	90	45	1	41	43	46	35	301
Roofing	D:	12,851	3234	23277	1199	708	1116	2403	44788
	N:	548	168	1131	62	43	70	88	2110
Out of plumb	D:	29,954	4387	651	1970	1985	844	830	40621
	N:	324	82	7	46	63	26	41	589
Doors	D:	10,835	7879	2696	83	791	66	827	23177
	N:	597	463	243	6	59	11	65	1444
Off foundation	D:	9,236	2787	60	1387	1787	1780	910	17947
	N:	71	55	1	36	35	65	38	301
Glass	D:	568	0	4107	384	0	399	644	6102
	N:	77	0	504	54	0	66	34	735
Roof off	D:	8,569	1681	130	1266	1815	642	478	14581
	N:	105	39	10	15	20	13	10	212
End or side out	D:	8,258	688	0	1498	703	867	336	12850
	N:	97	13	0	22	18	21	12	183
Paint damaged	D:	32	0	131	0	0	14	0	177
	N:	5	0	7	0	0	1	0	13
Misc. damage	D:	1,579	846	1311	459	61	169	978	5403
	N:	83	22	80	23	5	10	18	241
Addition	D:	4,181	0	998	0	0	0	0	5179
	N:	40	0	11	0	0	0	0	51
Cupola	D:	4,256	492	0	0	0	0	0	4748
	N:	186	29	0	0	0	0	0	215

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Table VII (Cont'd)

		Barn	Crib	Dwelling	Hog house	Mach. house	Poult. house	Misc. bldg.	Total
Chimney	D:	0:	0:	2221:	0:	0:	0:	0:	2221
	N:	0:	0:	112:	0:	0:	0:	0:	112
Porch	D:	0:	0:	1540:	0:	0:	0:	0:	1540
	N:	0:	0:	64:	0:	0:	0:	0:	64
Total	D:	161632:	35704:	38322:	19032:	17129:	12447:	11366:	295632
	N:	2223:	916:	2171:	305:	286:	329:	341:	6571

D - Damage
N - Number

Table VIII

DAMAGE TO IOWA FARM BUILDINGS BY HAIL IN 1946

		Barn	Crib	Dwelling	Hog house	Mach. house	Poult. house	Misc. bldg.	Total
Demolished	D:	0:	150:	0:	0:	0:	214:	0:	364
	N:	0:	1:	0:	0:	0:	2:	0:	3
Roofing	D:	3,284:	949:	12943:	919:	248:	438:	1,215:	19,996
	N:	99:	45:	308:	35:	12:	33:	56:	588
Out of plumb	D:	135:	0:	0:	0:	0:	0:	7:	142
	N:	2:	0:	0:	0:	0:	0:	1:	3
Doors	D:	53:	14:	189:	0:	12:	0:	0:	268
	N:	4:	2:	11:	0:	1:	0:	0:	18
Off foundation	D:	24:	0:	0:	0:	0:	168:	0:	192
	N:	4:	0:	0:	0:	0:	2:	0:	4
Glass	D:	781:	0:	5603:	646:	0:	540:	1,523:	9,093
	N:	91:	0:	502:	71:	0:	77:	40:	781
Roof off	D:	46:	0:	0:	0:	0:	0:	0:	46
	N:	1:	0:	0:	0:	0:	0:	0:	1
End or side out	D:	0:	0:	0:	0:	0:	0:	0:	0
	N:	0:	0:	0:	0:	0:	0:	0:	0
Paint damaged	D:	1,909:	673:	6195:	146:	73:	131:	91:	9,218
	N:	71:	36:	199:	15:	7:	12:	10:	350
Misc. damage	D:	21:	252:	1242:	73:	36:	216:	269:	2,109
	N:	2:	15:	42:	3:	4:	8:	9:	83
Addition	D:	0:	0:	0:	0:	0:	0:	0:	0
	N:	0:	0:	0:	0:	0:	0:	0:	0
Cupola	D:	0:	0:	0:	0:	0:	0:	0:	0
	N:	0:	0:	0:	0:	0:	0:	0:	0
Chimney	D:	0:	0:	154:	0:	0:	0:	0:	154
	N:	0:	0:	9:	0:	0:	0:	0:	9
Porch	D:	0:	0:	280:	0:	0:	0:	0:	280
	N:	0:	0:	9:	0:	0:	0:	0:	9
Total	D:	6,253:	2,038:	26606:	1,784:	369:	1,707:	3,105:	41,862
	N:	272:	99:	1080:	124:	24:	134:	116:	1,849

D - Damage N - Number

Table IX

DAMAGE TO IOWA FARM BUILDINGS BY FLYING DEBRIS IN 1946

		Barn	Crib	Dwelling	Hog house	Mach. house	Poult. house	Misc. bldg.	Total
Demolished	D:	0	0	0	0	0	0	80	80
	N:	0	0	0	0	0	0	1	1
Roofing	D:	458	274	358	219	39	45	22	1,415
	N:	8	13	9	5	3	2	2	42
Out of plumb	D:	0	40	0	30	0	0	17	87
	N:	0	1	0	1	0	0	1	3
Doors	D:	8	5	0	0	0	0	10	23
	N:	1	1	0	0	0	0	1	3
Off foundation	D:	0	0	0	0	0	0	0	0
	N:	0	0	0	0	0	0	0	0
Glass	D:	5	0	151	0	0	10	0	166
	N:	1	0	8	0	0	1	0	10
Roof off	D:	0	23	94	0	0	0	0	117
	N:	0	1	1	0	0	0	0	2
End or side out	D:	53	32	0	0	29	75	22	211
	N:	3	1	0	0	1	3	1	9
Paint damaged	D:	60	13	70	0	0	0	0	143
	N:	3	3	1	0	0	0	0	7
Misc. damage	D:	32	34	899	0	0	4	41	1,010
	N:	2	2	6	0	0	1	2	13
Addition	D:	0	0	0	0	0	0	0	0
	N:	0	0	0	0	0	0	0	0
Cupola	D:	0	0	0	0	0	0	0	0
	N:	0	0	0	0	0	0	0	0
Chimney	D:	0	0	0	0	0	0	0	0
	N:	0	0	0	0	0	0	0	0
Porch	D:	0	0	0	0	0	0	0	0
	N:	0	0	0	0	0	0	0	0
Total	D:	616	421	1,578	249	68	134	192	3,258
	N:	18	22	26	6	4	7	8	91

D - Damage N - Number

Table X

DAMAGE TO IOWA FARM BUILDINGS BY FALLING TREES IN 1946

		Barn	Crib	Dwelling	Hog house	Mach. house	Poult. house	Misc. bldg.	Total
Demolished	D:	0:	175:	0:	100:	0:	117:	0:	392
	N:	0:	1:	0:	1:	0:	1:	0:	3
Roofing	D:	414:	617:	3,117:	470:	843:	882:	619:	6,962
	N:	20:	22:	82:	15:	27:	25:	31:	222
Out of plumb	D:	0:	41:	0:	0:	128:	50:	0:	219
	N:	0:	1:	0:	0:	3:	1:	0:	5
Doors	D:	40:	0:	47:	0:	0:	0:	0:	87
	N:	1:	0:	4:	0:	0:	0:	0:	5
Off foundation	D:	0:	0:	0:	0:	0:	0:	0:	0
	N:	0:	0:	0:	0:	0:	0:	0:	0
Glass	D:	5:	0:	334:	5:	0:	0:	0:	344
	N:	1:	0:	37:	1:	0:	0:	0:	39
Roof off	D:	393:	94:	145:	100:	14:	102:	50:	898
	N:	5:	4:	10:	3:	2:	7:	4:	35
End or side out	D:	37:	273:	0:	0:	220:	25:	0:	555
	N:	3:	2:	0:	0:	1:	1:	0:	7
Paint damaged	D;	62:	0:	86:	0:	0:	0:	0:	148
	N:	2:	0:	3:	0:	0:	0:	0:	5
Misc. damage	D:	111:	27:	523:	0:	20:	121:	105:	907
	N:	6:	1:	20:	0:	3:	3:	5:	38
Addition	D:	66:	0:	35:	0:	0:	0:	0:	101
	N:	2:	0:	1:	0:	0:	0:	0:	3
Cupola	D:	0:	0:	0:	0:	0:	0:	0:	0
	N:	0:	0:	0:	0:	0:	0:	0:	0
Chimney	D:	0:	0:	500:	0:	0:	0:	0:	500
	N:	0:	0:	25:	0:	0:	0:	0:	25
Porch	D:	0:	0:	568:	0:	0:	0:	0:	568
	N:	0:	0:	18:	0:	0:	0:	0:	18
Total	D:	1,128:	1,227:	5,355:	675:	1,225:	1,297:	774:	11,681
	N:	40:	31:	200:	20:	36:	38:	40:	405

D - Damage N - Number

Table XI

DAMAGE TO IOWA FARM BUILDINGS BY OTHER CAUSES IN 1946

		Barn	Crib	Dwelling	Hog house	Mach. house	Poult. house	Misc. bldg.	Total
Demolished	D:	1,191	0	0	0	0	300	30	1,521
	N:	2	0	0	0	0	1	1	4
Roofing	D:	47	134	49	0	0	5	20	255
	N:	2	3	1	0	0	1	1	8
Out of plumb	D:	57	0	0	0	0	0	0	57
	N:	1	0	0	0	0	0	0	1
Doors	D:	46	0	0	0	0	0	0	46
	N:	1	0	0	0	0	0	0	1
Off foundation	D:	0	0	0	0	0	0	0	0
	N:	0	0	0	0	0	0	0	0
Glass	D:	0	0	4	0	0	0	0	4
	N:	0	0	1	0	0	0	0	1
Roof off	D;	55	0	0	0	0	0	0	55
	N:	2	0	0	0	0	0	0	2
End or side out	D:	0	0	0	0	0	0	0	0
	N:	0	0	0	0	0	0	0	0
Paint damaged	D:	0	0	0	0	0	0	0	0
	N:	0	0	0	0	0	0	0	0
Misc. damage	D:	0	0	33	0	0	0	0	33
	N:	0	0	1	0	0	0	0	1
Addition	D:	50	0	0	0	0	0	0	50
	N:	1	0	0	0	0	0	0	1
Cupola	D:	0	0	0	0	0	0	0	0
	N:	0	0	0	0	0	0	0	0
Chimney	D:	0	0	0	0	0	0	0	0
	N:	0	0	0	0	0	0	0	0
Porch	D:	0	0	0	0	0	0	0	0
	N:	0	0	0	0	0	0	0	0
Total	D:	1,446	134	86	0	0	305	50	2,021
	N:	9	3	3	0	0	2	2	19

D - Damage N - Number

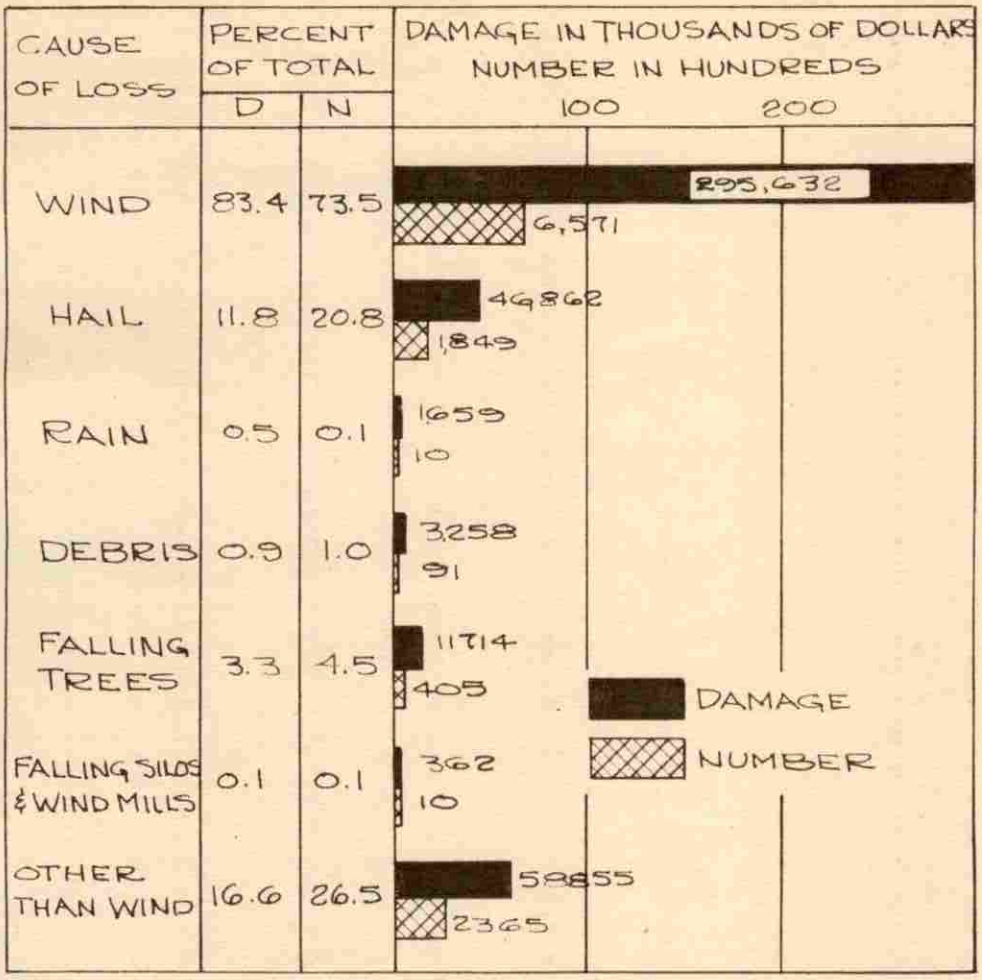

FIG. 12 WIND DAMAGE TO IOWA FARM BUILDINGS BY CAUSE IN 1946

of wind acting directly on the structure or item damaged. Hail accounted for 11.8 per cent of the damage and 20.8 per cent of all damages. The larger percentage figure for the number of damages brings out the fact that the hail claims were smaller in magnitude of loss than were the wind claims.

Falling trees accounted for $11,714.00 damage in 1946. Generally, this type of damage resulted in trees falling on roofs or cornices of buildings or onto machinery. This type of damage is a result of negligence in many cases. Dead and weak trees should be trimmed away or removed from the vicinity of buildings, and farm machinery should not be parked in groves. Damage from debris was usually a result of parts of demolished or wind-damaged buildings blowing away and damaging other buildings.

Rain damage was to contents of buildings, mostly feeds, after the building had been damaged or demolished by wind.

Falling silos and windmills which damaged other buildings were few.

Constructional Damage Due Directly to Wind

Type of damage

Inasmuch as 83.4 per cent of all damage and most of the constructional damage which this study concerns was due to wind directly, Figure 13 was prepared in which amount of

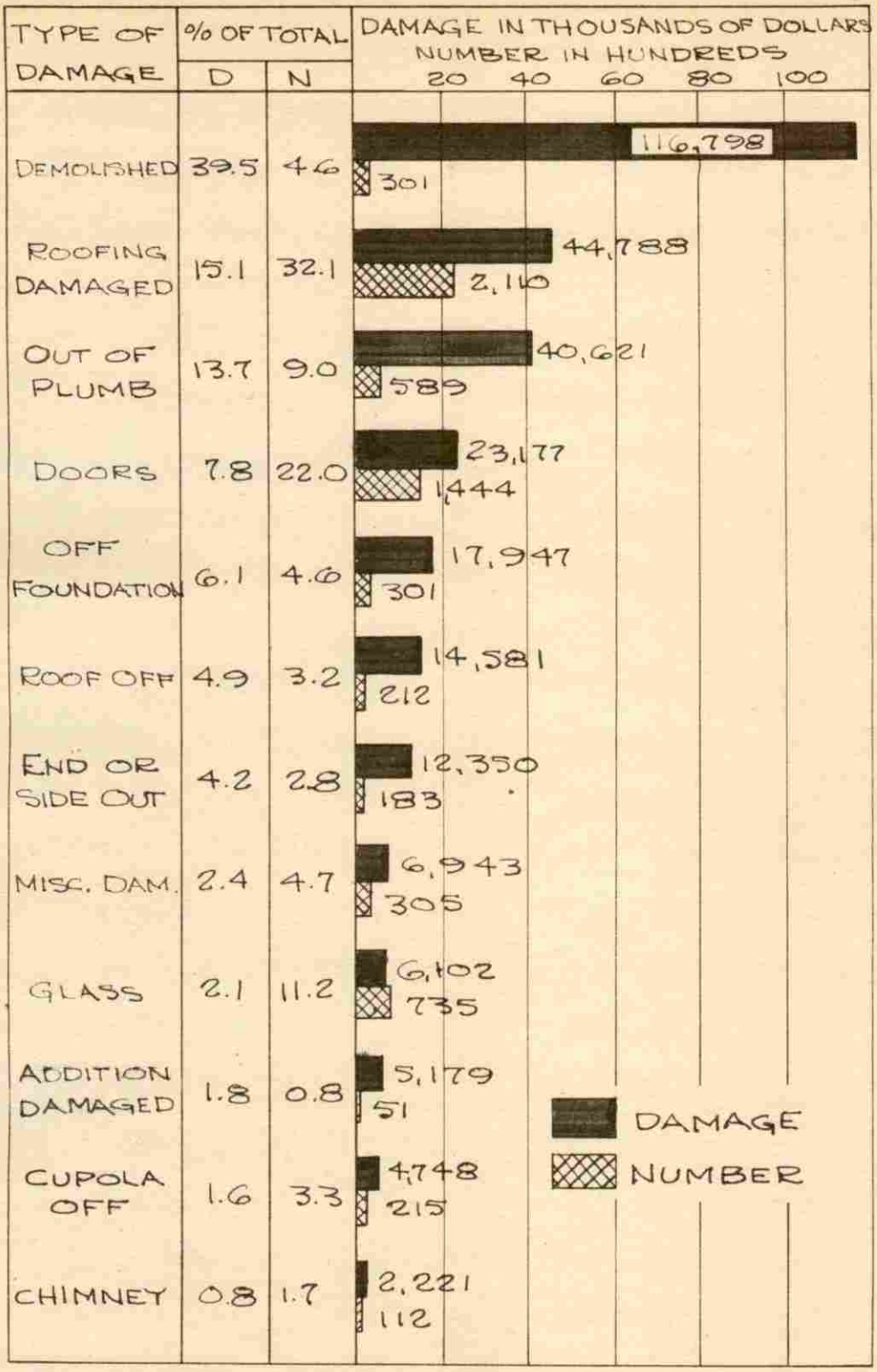

FIG. 13 DAMAGE TO IOWA FARM BUILDINGS DUE DIRECTLY TO WIND IN 1946

damage and number of damages caused by wind directly are shown for each of the twelve major types of damages. The types of damages are arranged in order of magnitude of loss. In comparison with Figure 10, which includes all causes, it is noted that there is some rearrangement of the types of damages as to magnitude of loss and replacement of one type of damage for another. Damage to paint and siding was due mostly to hail so was insignificant in an analysis of damage due directly to wind. Damage to chimneys was found to be the next type of damage in line. In Figure 13 chimney damage was included in miscellaneous damage.

Demolition of buildings, being a result of direct wind, heads the list for amount of damage. Due to the smaller total amount of damage caused by wind directly, demolition of buildings accounted for 39.5 per cent of the damage in comparison to 33.7 per cent when considering all causes.

The percentage of wind damage to roofing dropped 5.6 per cent because a lot of the roofing damage was caused by hail. The percentage of number of roofing damages due to wind stayed nearly constant. This indicates that roofing damages resulted from both wind and hail.

Damages as out of plumb, doors damaged, off foundation, roof off, and end or side out were caused mostly by direct wind action. Over half of the damage to window glass was caused by reasons other than direct wind.

Damage by type of buildings

In order to narrow down further the constructional damage to farm buildings, Figure 14 was prepared to show damage to different farm buildings due directly to wind. In considering only wind damage to buildings, damage to barns accounted for over half of the total. The damage from the direct action of wind on the dwelling was only about half of that resulting from all causes. The per cent of damage to dwellings being 15.1 per cent is only slightly above that of corn cribs in considering direct wind action only.

The buildings included under the heading "miscellaneous buildings" were mostly garages, fuel houses, summer kitchens, and a few country churches and schoolhouses.

Demolition of buildings

Giese (8) states that, "From observations in storm areas, the improper fastening of plates and rafters to the top of a frame wall appears to be the most common cause for destruction of buildings in a high wind."

For a thorough analysis of demolished buildings, it would be necessary to know in each case what part of the structure failed first. Inasmuch as the 312 buildings demolished in 1946 were not observed personally, only the information available on the proofs of loss concerning these buildings is considered in this study.

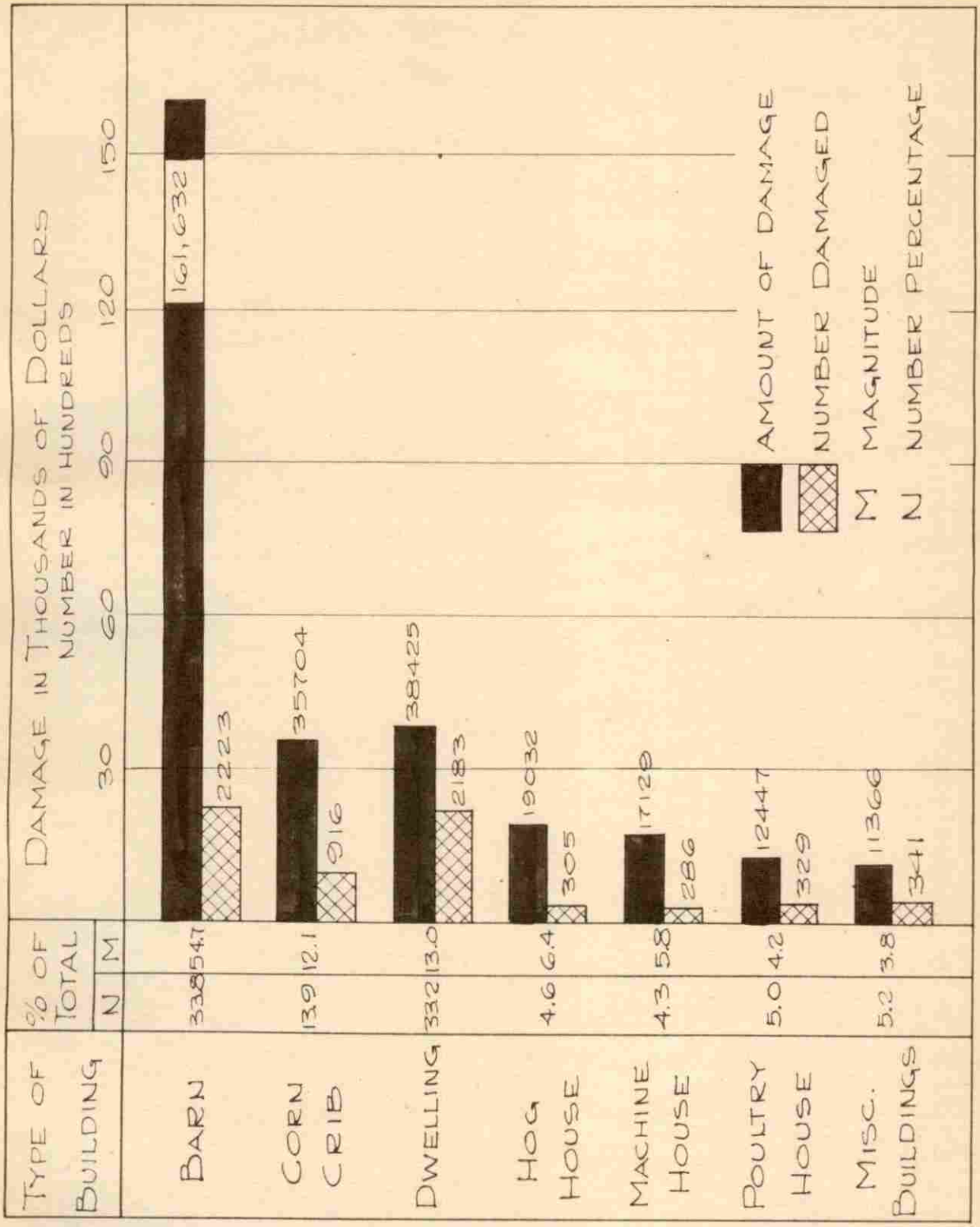

Fig. 14 Structural Damage to Farm Buildings Due Directly to Wind

To determine more definitely which type of buildings were demolished most frequently, Figure 15 was prepared. This illustrates that the barn suffered 61.1 per cent of the loss due to demolition of buildings. In contrast, the dwelling suffered only 1 per cent of the damage; only one house valued at $1,200.00 being demolished. Although demolition of dwellings accounted for only 1 per cent of the loss, they represent nearly half of the investment in all farm buildings, as indicated in Figure 2.

The loss resulting from demolition of buildings averaged $388.00 for all buildings and $792.00 for barns. In an analysis of the evaluation of barns demolished, Figure 16 illustrates the relation between the insured value of barns demolished and those damaged. In considering distribution by insurance value, 30 per cent of the barns demolished were insured for less than $250.00 in contrast to less than 5 per cent of the barns being insured for that small amount. The percentage peak of number damaged appears in the group of barns insured for between $750.00 and $1,000.00. This peak lacks 5 per cent of reaching the percentage peak of demolished barns insured for less than $250.00.

Some buildings may be under insured but there is no reason why barns being demolished should be under insured any more than others. The only substantial reason for the large number of buildings with low insurance coverage being demolished is that the buildings of low value are the

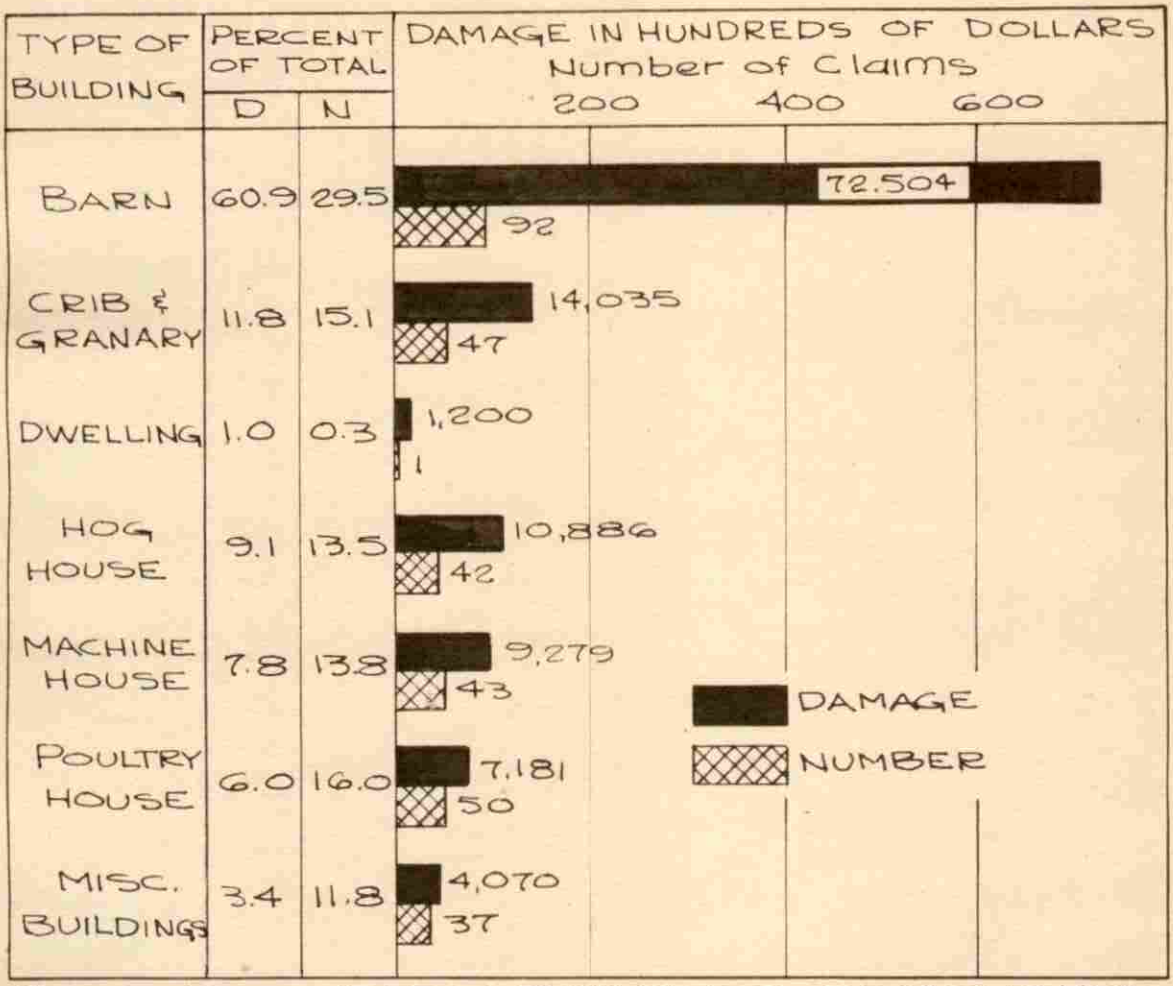

FIG. 15 IOWA FARM BUILDINGS DEMOLISHED BY WIND IN 1946

FIG. 16 INSURANCE ON BARNS DEMOLISHED COMPARED WITH BARNS DAMAGED

weakest ones of poor construction and have a tendency to collapse first.

Buildings out of plumb

Wind losses due to buildings being blown out of plumb, as indicated in Figure 13, accounted for 13.7 per cent of the total constructional damage to farm buildings. Figure 17 illustrates that 73.1 per cent of all damage caused by buildings being blown out of plumb in 1946 was to barns. Of this amount, 54.1 per cent of the damages involved were to barns. Next in magnitude of damage were corn cribs with 10.9 per cent of the damage and 14.0 per cent of the damage claims. Damage to dwellings by this cause is very small, as it was for demolition. The other farm buildings being small structures, generally were not subject to being blown out of plumb as readily as the larger storage buildings and barns. The average damage to barns resulting from being blown out of plumb was a little less than $100.00.

Even though the buildings were straightened and put back in shape for around a hundred dollars, the buildings were permanently weakened. Every joint in the barn or other building had to undergo twisting and slipping of some nature when the structure was blown out of plumb. Unless sufficient additional bracing was placed in the building, it would have an increased tendency to go out of plumb the second or any succeeding time more readily.

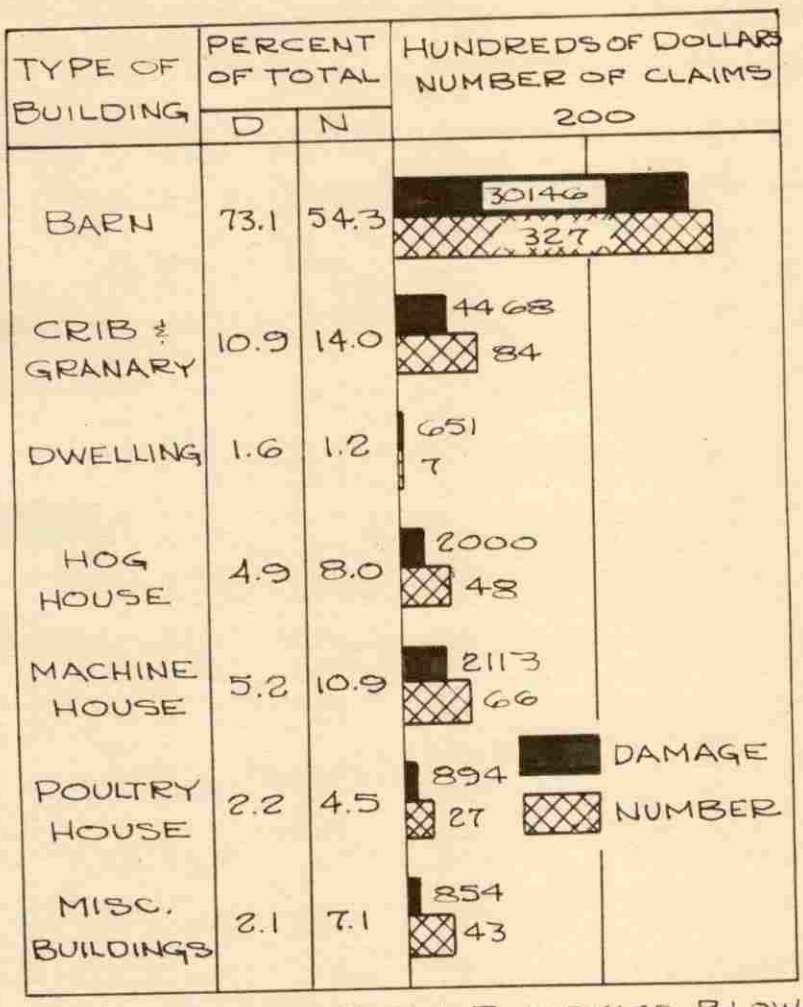

FIG. 17 IOWA FARM BUILDINGS BLOWN OUT OF PLUMB IN 1946

Table XII

MAGNITUDE OF INSURANCE COVERAGE ON IOWA FARM BARNS DAMAGED IN 1946

Magnitude	Number	Amount of claims	Amount of insurance
0 - 250	117	6,222	19,871
251 - 500	256	13,497	107,650
501 - 750	196	9,610	129,050
751 - 1,000	644	34,253	606,125
1,001 - 1,250	212	8,085	252,625
1,251 - 1,500	230	33,248	335,205
1,501 - 1,750	290	16,828	449,708
1,751 - 2,000	365	27,667	709,200
2,001 - Over	253	21,700	730,600
Total	2,563	171,110	3,340,034

Table XIII

MAGNITUDE OF INSURANCE COVERAGE ON IOWA FARM BARNS DEMOLISHED IN 1946

Magnitude	Number	Amount of claims	Amount of insurance
0 - 250	28	3,498	3,771
251 - 500	17	6,675	7,000
501 - 750	6	3,400	3,700
751 - 1,000	11	8,975	10,000
1,001 - 1,250	1	1,200	1,200
1,251 - 1,500	14	20,306	20,750
1,501 - 1,750	4	6,050	6,450
1,751 - 2,000	7	13,500	13,500
2,000 - Over	4	8,900	9,800
Total	92	72,504	76,171

Wind Damage Trends

Wind loss by type of damage

Wind data recorded and analyzed previous to 1946 was during the four-year period of 1930 to 1933 by Schweers (15) and Clark (3) and others. In order to arrive at a comparison between the data taken at that time and the present data, Tables XIV and XV were prepared showing loss and number of damages by type of building and damage. Figure 18 represents the losses from the different types of damage graphically by per cent of total loss. The average annual losses were used for the four-year period of 1930 to 1933. Only for three of the thirteen types of damages was the per cent of total loss higher in 1946 than for the 1930 to 1933 period; however, only in demolition of buildings was the percentage appreciably lower in 1946, showing a decrease of 13.2 per cent of the total damage.

Of the three types of damage for which an increase was shown in 1946 only one was for an appreciable amount. That was in damage to roofing material, which increased in magnitude of loss by 14.8 per cent of the total annual damage. This was an increase of nearly 200 per cent over that of 1930 to 1933. During the period 1930 to 1933 the average loss from demolition of buildings was 6.33 times as great as from roofing damage, but in 1946 losses from demolition accounted for only 1.62 times as much as did damaged roofing.

The loss from wind damaged doors increased from 3 to 7

Table XIV

CONSTRUCTIONAL DAMAGE TO IOWA FARM BUILDINGS
DUE DIRECTLY TO WIND

	Average of 1930 to 1933				1946			
	Damage	%	No.	%	Damage	%	No.	%
Barn	111,122	55.8	992	26.3	161,632	55.8	2,223	33.8
Crib and granary	15,914	8.0	402	10.7	35,704	12.1	916	14.0
Dwelling	11,070	5.7	333	8.8	38,322	13.0	2,171	33.1
Hog house	14,031	7.0	193	5.1	19,032	6.4	305	4.6
Machine house	11,421	5.7	242	6.4	17,129	5.8	286	4.3
Poultry house	9,955	5.0	222	5.9	12,447	4.2	329	5.0
Unspecified	25,564	12.8	1,387	36.8	11,366	3.8	341	5.2
Total	199,079	100.0	3,769	100.0	295,632	100.0	6,571	100.0

Table XV

WIND DAMAGE TO IOWA FARM BUILDINGS BY ALL CAUSES

	Average of 1930 to 1933				1946			
	Damage	%	No.	%	Damage	%	No.	%
Demolished	112,094	48.1	353	5.8	119,155	34.9	312	3.4
Out of plumb	29,237	12.5	726	12.1	41,126	12.1	602	6.9
Roofing	17,818	7.6	1,152	19.2	73,416	21.5	2,970	34.0
Roof off	15,505	6.7	316	5.3	15,697	4.6	252	2.9
Glass	14,462	6.2	1,456	24.1	15,709	4.6	1,566	17.9
Off foundation	14,495	6.2	432	7.2	18,139	5.3	305	3.5
Doors	6,926	3.0	625	10.4	23,601	6.9	1,471	16.9
Cupola	5,550	2.4	251	4.2	4,748	1.4	215	2.5
Unspecified	4,661	2.0	220	3.7	9,462	2.8	376	4.3
Addition	3,687	1.6	62	1.0	5,330	1.6	55	0.6
Paint damaged	3,613	1.5	150	2.5	9,686	2.8	375	4.3
Chimney	2,323	1.1	192	3.2	2,875	0.8	146	1.7
Porch	2,522	1.1	76	1.3	2,394	0.7	92	1.1
Total	232,893	100.0	6,011	100.0	341,338	100.0	8,737	100.0

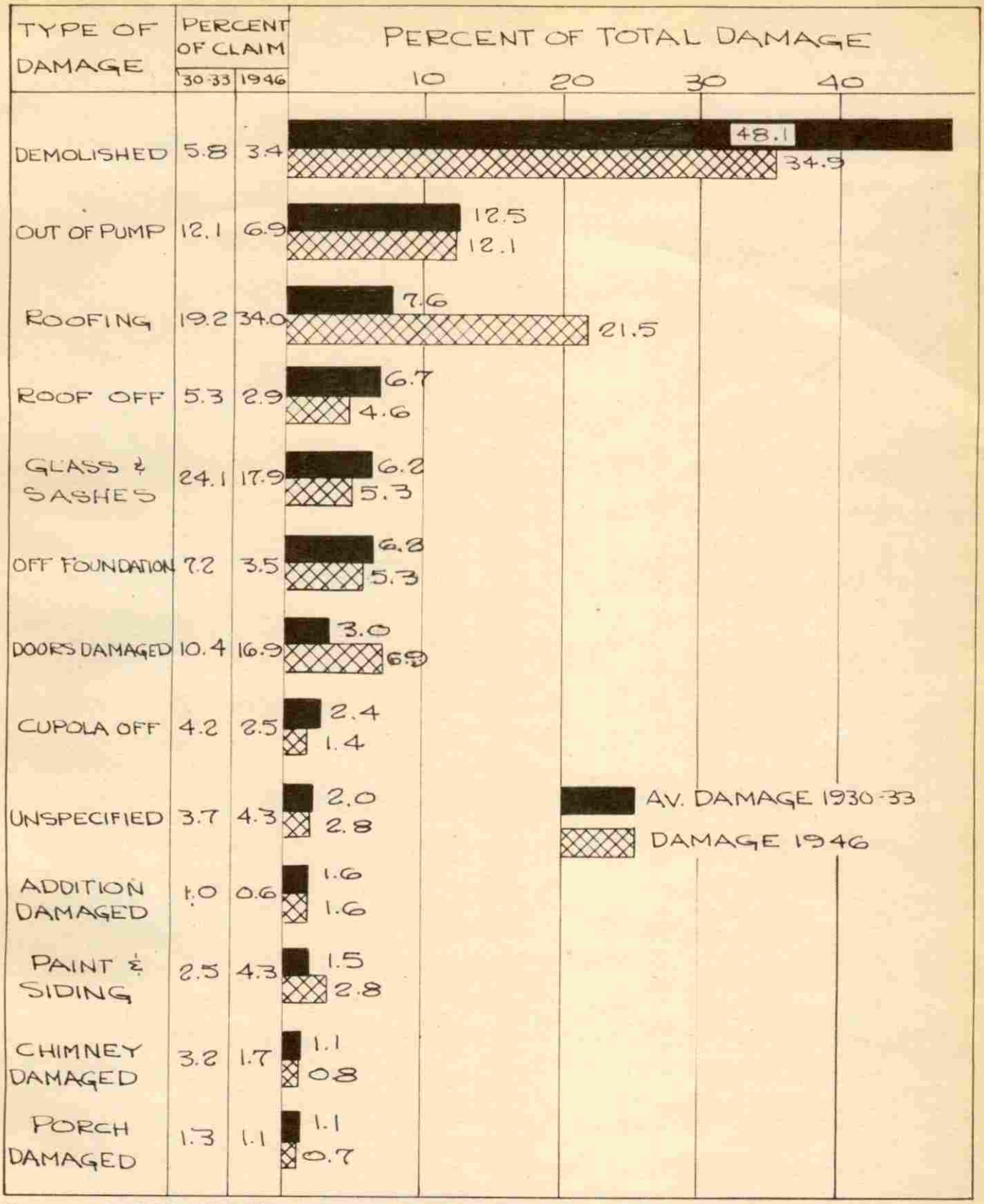

FIG. 18 WIND DAMAGE BY ALL CAUSES 1930-33 AND 1946

per cent of the total loss, from 1930-33 to 1946. The types of doors accounting for most of the damage in 1946 were hay doors, and large driveway doors on corn cribs and machine sheds. Damage to doors is a type of damage that results mainly from carelessness on the part of the farm operator inasmuch as the doors are not kept latched shut or open securely and are not maintained properly to prevent the wind from swinging them loose and off from their hinges.

The third type of damage showing an increase was that of damage to paint and siding. This increase was from 1.5 to 2.8 per cent of the total, which is not significant, inasmuch as most of this type of damage is a result of hail, and the number and severity of hail storms could easily have varied that much for different years.

A more detailed analysis of the large increase in roofing damage will be made later in the results and findings of this document. This increase can hardly be skipped over as coincidental, because it puts this type of damage second only to demolition of buildings in magnitude of loss and it accounted for a higher per cent of the total damages than any other type of damage. One out of every three damages recorded in 1946 was to roofing.

Wind loss by type of building

In comparing wind damage to the farm buildings during

the period of 1930-33 with 1946 there was found to be very little difference in the magnitude of losses. Figure 19 indicates that only two types of buildings, dwellings and corn cribs, showed an increase in per cent of total damage from 1930-33 to 1946.

There was one noted decrease and that was in damage to miscellaneous buildings or of those unspecified. This was undoubtedly due to a somewhat difference in the method of recording claims and in the fact that the present proofs of loss received by the Association from the various agents are perhaps more completely filled out than they were previously. This would tend to eliminate the group of buildings listed as unspecified, and leave only miscellaneous buildings which are those other than the six classified types of farm buildings.

The barn accounted for over half of the total wind damage for both periods. The only significant increase was in damage to dwellings which more than doubled in per cent of total loss. This increase can be accounted for mostly by the increase in damage to roofing for which the dwelling showed the greatest increase.

Magnitude of Wind Damage Losses

Magnitude by type of buildings

In considering damage by all causes, Figure 20 was

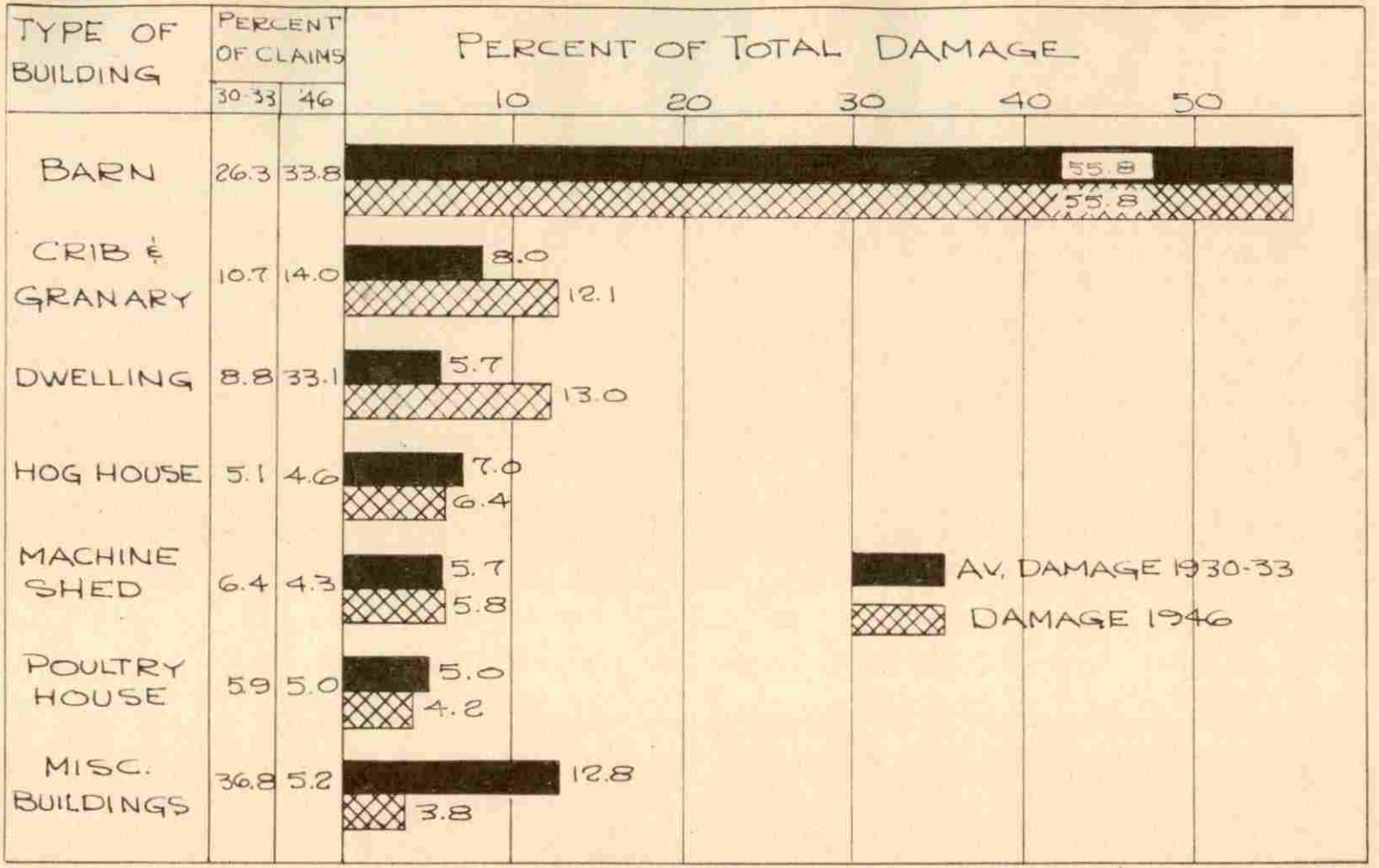

FIG. 19 CONSTRUCTION DAMAGE TO FARM BUILDINGS DUE DIRECTLY TO WIND

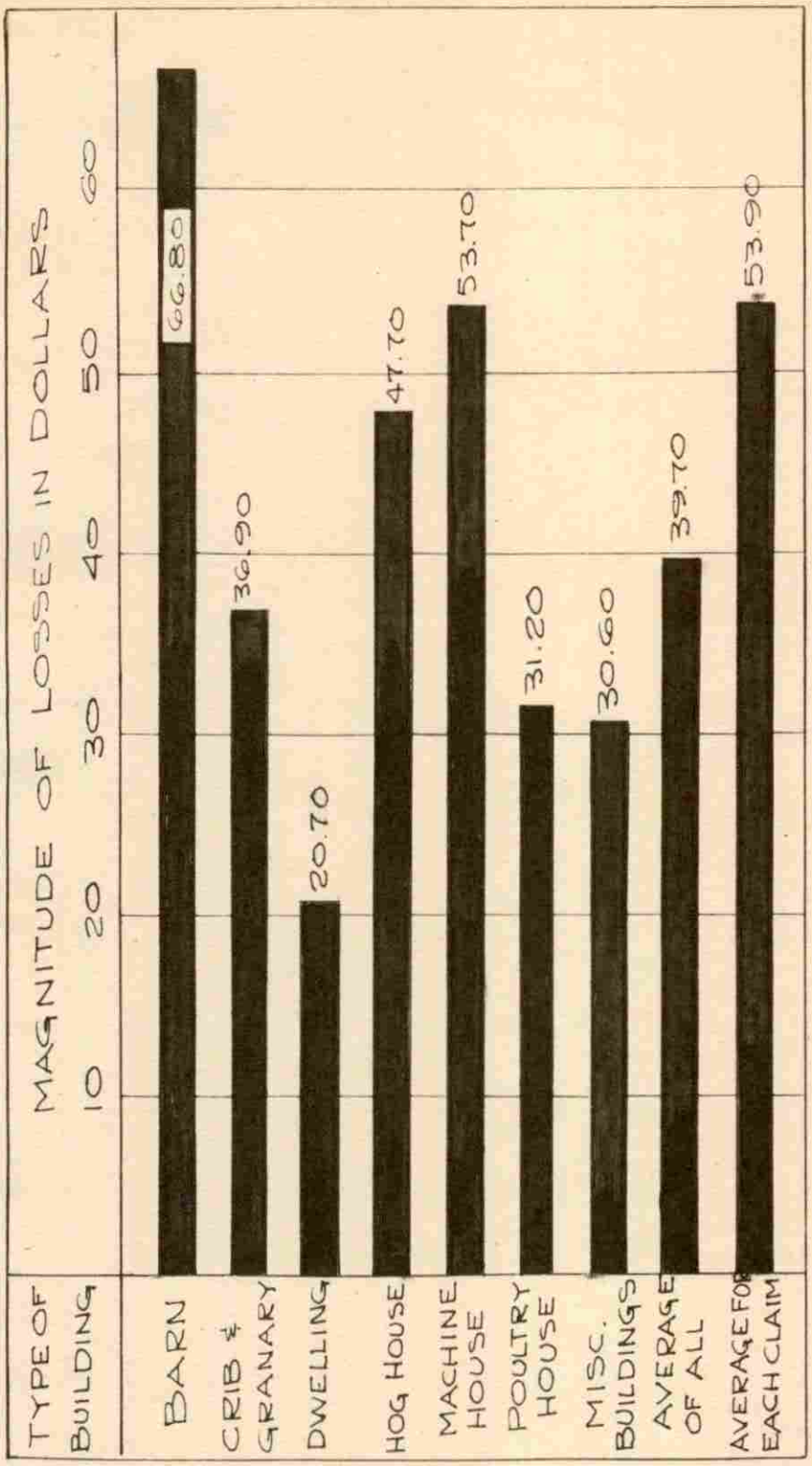

FIG. 20 AVERAGE MAGNITUDE OF WIND LOSSES TO IOWA FARM BUILDINGS IN 1946

prepared to illustrate the variance in the average magnitude of loss among the different types of farm buildings. The barn, which accounted for the highest average loss per damage of all the farm buildings, also accounted for the most damage as shown by Figure 11. It is believed that this is due to the fact that except for the farm dwelling the barn is valued at more than any of the other farm buildings, but is not built as wind resistant for its size as the dwelling, which accounts for nearly half of the investment in farm buildings but suffers the smallest amount of damages. The small claims on the dwellings are due to the minor type of the damages it sustains, such as roofing and paint damage and glass and doors broken, rather than major structural failures.

The average magnitude of wind damage claims was $39.70 per damage, while for each claim it was $53.90. This difference is accounted for by the fact that many of the claims contained more than one damage; for example, one claim may be for both a damaged roof on the dwelling and a damaged door on the corn crib, both buildings being covered by the same policy and suffering wind damage simultaneously.

Distribution of damages

In analyzing the distribution of the wind damages by magnitude, Figures 21, 22 and 23 were prepared on which per

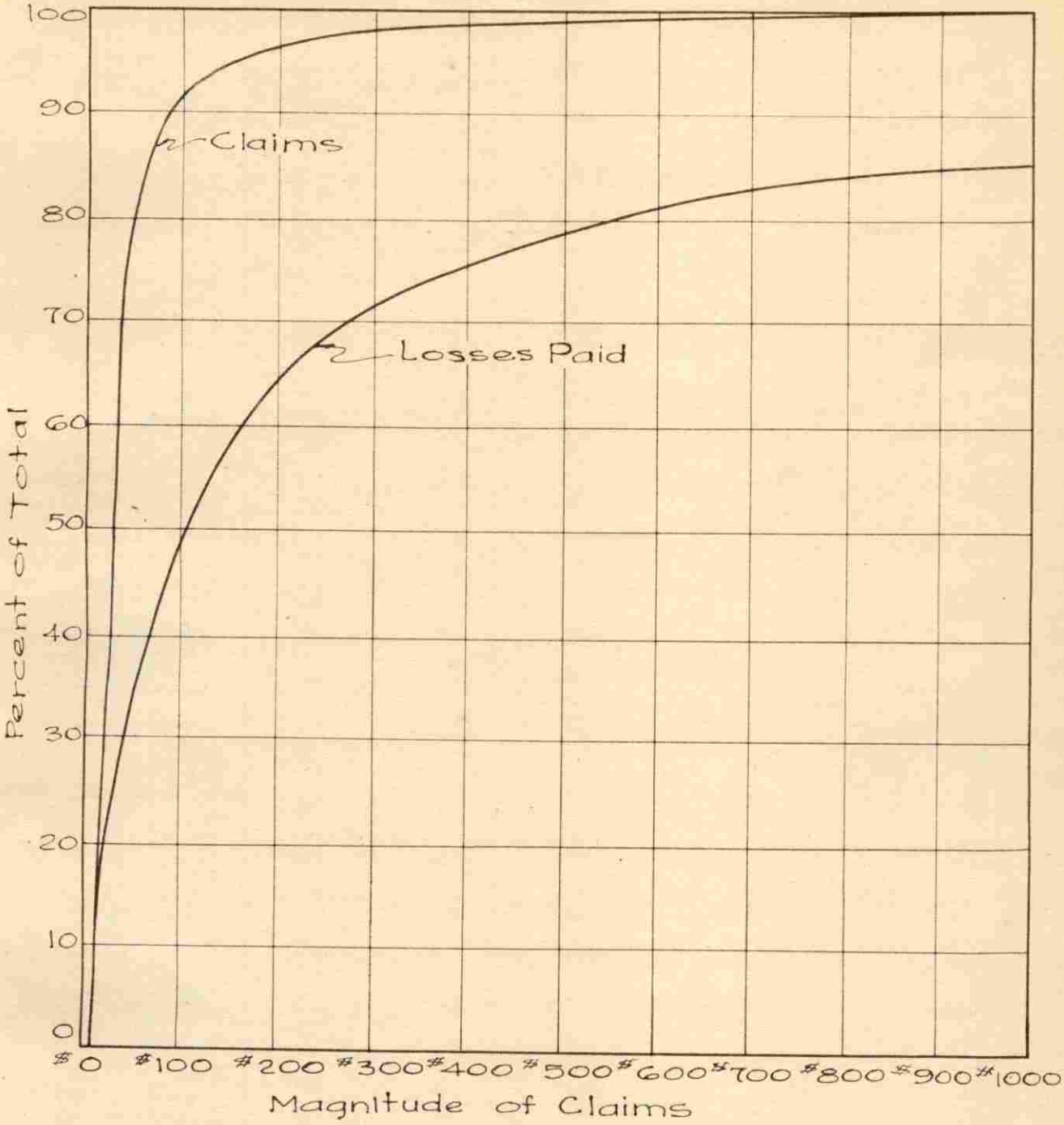

Fig. 21 DISTRIBUTION OF WIND DAMAGE CLAIMS IN 1946 0 TO $1000

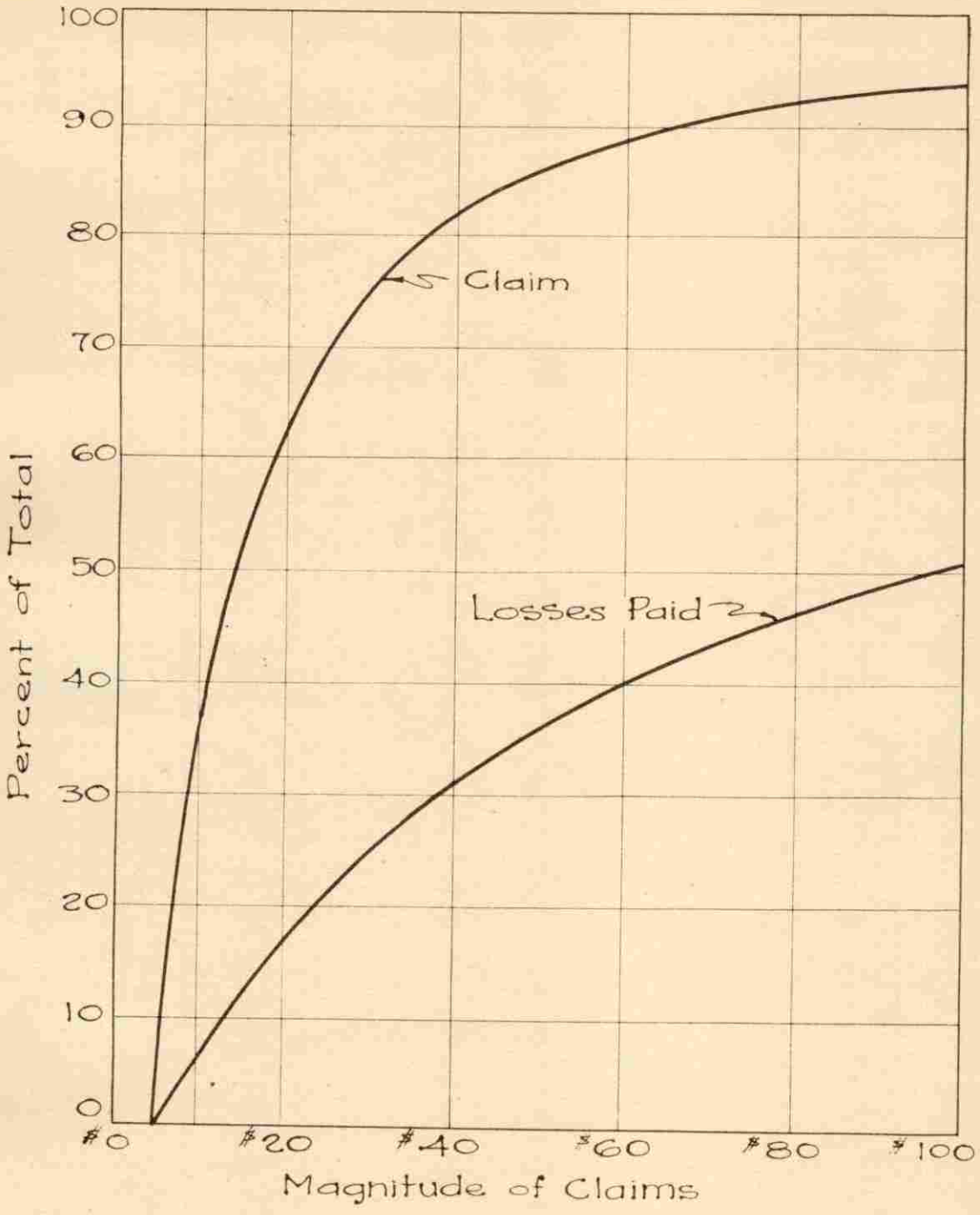

Fig. 22 DISTRIBUTION OF WIND DAMAGE CLAIMS IN 1946 0 TO $100

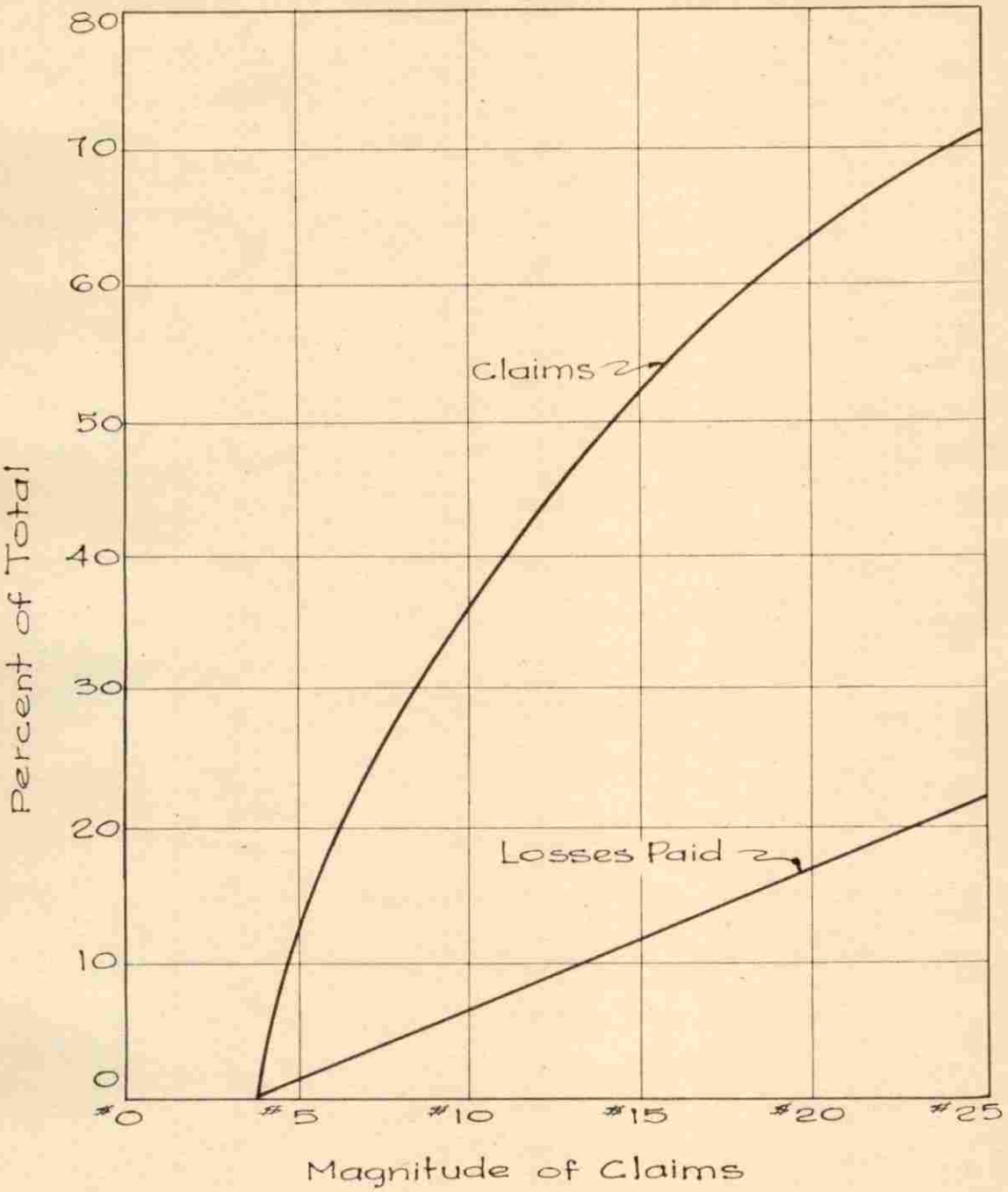

Fig. 23 DISTRIBUTION OF WIND DAMAGE CLAIMS IN 1946 0 TO #25

cent was plotted against magnitude of damage. In all three figures, magnitude of individual damages are considered and not claims which might include one or more damages on each.

In the three figures it is apparent that the percentage of damages by number runs much higher for the lower magnitude damages than does the amount of losses. In magnitude of loss a few $1,000.00 damages add up very rapidly, but in number of damages at the same rate as for $5.00 damages or any other size. Table XVI lists 9,621 damages or about 93 per cent of the damages which for less than $100.00 each, but only 50 per cent of the magnitude of the damage was represented by damages of that size. There were only thirty-five damages for more than $1,000.00 in 1946, although these few damages accounted for 14.3 per cent of the total damages paid.

In Figure 22, only damages under $100.00 were considered It is illustrated that the percentage curve for losses paid is nearly straight while for number of damages it rises very rapidly from $5.00 damages to above 60 per cent, which includes only damages for less than $20.00. A $5.00 claim is the smallest that the Association will accept, although separate damages may be for less if two or more are included on one claim.

In a more detailed breakdown of damages for less than $25.00, Figure 23 was prepared. A straight line curve is formed by the percentages of losses paid. In per cent of

Table XVI

MAGNITUDE OF WIND DAMAGE

Magnitude	Number	Amount of claims	Amount of insurance
0 - 5	1,196	5,181	1,696,340
6 - 10	2,518	20,568	3,822,640
11 - 15	1,622	21,526	2,435,585
16 - 20	1,100	20,130	1,525,465
21 - 25	826	19,533	1,116,820
26 - 50	1,579	57,574	2,204,413
51 - 75	505	32,075	660,830
76 - 100	275	24,983	357,380
101 - 200	382	55,844	470,020
201 - 300	107	27,968	101,575
301 - 400	45	17,215	75,000
401 - 500	20	9,053	51,000
501 - 600	13	7,539	17,550
601 - 700	9	5,962	12,000
701 - 800	10	7,868	10,900
801 - 900	4	3,509	5,550
901 - 1000	5	4,950	6,000
1001 - 1500	18	25,054	26,250
1501 - 2000	13	23,942	25,350
2001 - 2500	2	4,900	5,000
2501 - 3000	1	3,000	3,000
Total	10,250	398,374	
0 - 20	6,436	67,405	9,480,030
21 - 40	1,965	56,603	2,716,383
41 - 60	663	32,981	812,938
61 - 80	334	23,681	397,622
81 - 100	223	20,900	267,500
Total	9,621	201,570	

damages, 71 per cent are for damages of less than $25.00, while only 21.8 per cent of the losses paid were accounted for by these damages. Both curves originate to the left of the $5.00 line on Figure 23, indicating that some individual damages were received for less than the minimum of $5.00; this explained by the fact that more than one damage was reported on the same proof of loss in many cases. The number of damages of $5.00 or less, recorded in 1946, was 11.65 per cent of the total or 1,196 of the 10,250 damages analyzed.

Hail Damage to Iowa Farm Buildings

Type of damage

Damage to Iowa farm buildings by hail was found to be mainly of three types. They were damage to roofing, glass, and paint and siding. Figure 24 illustrates the amount of damage and number of damages for each of the three types of damage caused by hail and wind. Damage to roofing by hail showed the greatest loss. Hail damage accounted for 30.9 per cent of the damage to roofing by both wind and hail and 21.7 per cent of the damages. This stresses the point that the average magnitude of the hail damages on roofing damage were somewhat larger than the ones due to wind. The average for hail was $34.00 while for wind it was $21.20.

Hail accounted for more damage to windows in 1946 than

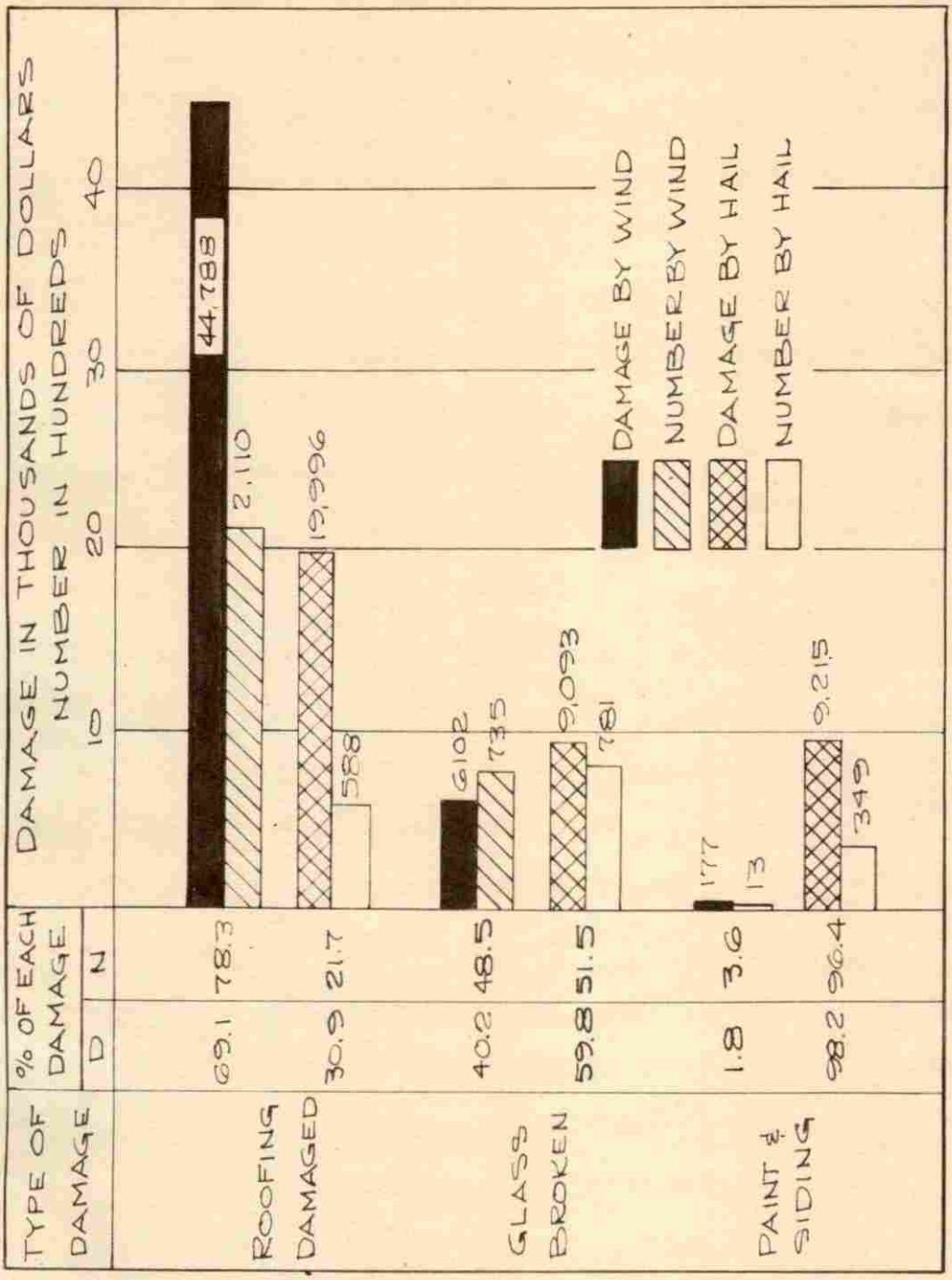

FIG. 24 HAIL DAMAGE TO IOWA FARM BUILDINGS BY TYPE OF DAMAGE IN 1946

did wind. The number of damages was split nearly even between the two causes, 731 being recorded for wind and 781 for hail.

Damage to paint and siding was due almost entirely to hail. In many cases the hail stones damaged the paint on buildings to the extent that entire repaint jobs were necessary. The preparation of the hail damaged surface also was a costly and time consuming task in many cases.

Distribution of hail storms

The distribution of hail damage by counties in 1946 is tabulated in Table XVII. Number of damages, amount of damage, and insurance coverage on buildings damaged is given for each county along with total risk in force, which was used in deriving the loss ratio. The loss ratio is the amount of loss or damage divided by the risk in force in thousands of dollars. Figure 25 illustrates the loss ratio graphically by counties. Harrison county received the only severe hail storm as far as building damage was concerned. Over $10,000.00 hail damage was reported for that county. Many claims were reported which included damages to paint, roofing and glass on nearly every building of the farmstead; the separate damages being small but the total quite large.

Distribution by month

Hail damage by month of the year for 1946 is given in Table XVIII and illustrated graphically in Figure 27. It is

Table XVII

DISTRIBUTION OF HAIL DAMAGE BY COUNTIES IN 1946

County	Risk in force	No. of losses	Amt. of damage	Building insurance	Loss/ $1,000 risk
Adair	$5,060,546	0	$ 0	$ 0	$.000
Adams	3,386,377	5	80	7,700	.024
Allamakee	6,821,795	0	0	0	.024
Appanoose	976,450	1	10	3,500	.010
Audubon	8,586,926	2	36	4,500	.004
Benton	8,535,461	2	103	20,500	.012
Black Hawk	8,204,944	1	18	2,000	.002
Boone	10,751,445	3	43	9,200	.004
Bremer	9,418,650	1	5	2,000	.001
Buchanan	4,892,010	0	0	0	.000
Buena Vista	19,145,258	14	282	27,125	.015
Butler	11,362,012	0	0	0	.000
Calhoun	9,953,171	6	55	14,500	.006
Carroll	5,707,022	8	114	18,125	.020
Cass	6,550,824	3	63	2,150	.010
Cedar	7,200,664	8	96	13,600	.013
Cerro Gordo	15,552,507	7	63	15,500	.004
Cherokee	13,407,244	10	833	9,310	.062
Chickasaw	10,327,941	19	375	31,750	.036
Clarke	440,430	36	685	42,770	1.555
Clay	20,588,930	5	44	6,100	.002
Clayton	15,268,331	1	5	1,600	.000
Clinton	6,099,440	0	0	0	.000
Crawford	952,325	0	0	0	.000
Dallas	8,987,640	30	946	41,000	.105
Davis	191,195	0	0	0	.000
Decatur	667,410	6	117	8,750	.176
Delaware	7,388,410	0	0	0	.000
Des Moines	3,790,600	3	30	1,550	.008
Dickinson	10,097,631	7	85	10,075	.008
Dubuque	2,877,730	0	0	0	.000
Emmet	9,109,653	40	766	66,600	.084
Fayette	13,269,239	7	72	15,700	.005
Floyd	9,920,606	11	174	19,050	.018
Franklin	18,638,040	12	111	24,600	.006

Continued on next page

Table XVII (Cont'd)

County	Risk in force	No. of losses	Amt. of damage	Building insurance	Loss/ $1000 risk
Fremont	$2,644,202	2	$ 80	$ 7,000	$.030
Greene	11,539,187	6	75	8,925	.007
Grundy	12,919,240	2	52	4,500	.004
Guthrie	5,730,228	3	84	6,500	.015
Hamilton	7,522,104	2	11	2,500	.001
Hancock	17,355,312	63	1,669	115,505	.096
Hardin	8,209,300	8	110	14,400	.013
Harrison	14,669,415	348	10,635	532,175	.725
Henry	8,129,738	1	368	2,000	.045
Howard	3,430,216	19	243	30,050	.071
Humboldt	13,815,301	0	0	0	.000
Ida	5,626,498	0	0	0	.000
Iowa	7,905,063	3	36	7,000	.005
Jackson	6,444,167	32	618	72,050	.096
Jasper	13,456,555	89	2,056	150,965	.153
Jefferson	3,758,610	26	1,159	37,525	.308
Johnson	7,463,578	5	66	10,300	.009
Jones	6,807,524	0	0	0	.000
Keokuk	7,137,748	38	704	53,100	.099
Kossuth	23,609,932	99	1,845	195,400	.078
Lee	1,419,600	2	45	2,800	.032
Linn	9,177,469	3	30	2,800	.003
Louisa	2,434,025	2	13	1,800	.005
Lucas	2,430,185	12	129	21,100	.053
Lyon	16,387,369	223	777	44,900	.047
Madison	5,864,070	25	735	45,350	.125
Mahaska	4,035,154	73	2,190	83,675	.544
Marion	2,960,894	69	1,871	116,675	.633
Marshall	10,696,566	0	0	0	.000
Mills	5,439,436	11	408	16,000	.075
Mitchell	12,593,923	6	114	16,400	.009
Monona	5,584,284	23	551	28,775	.099
Monroe	117,275	0	0	0	.000
Montgomery	8,212,462	5	77	10,400	.009
Muscatine	7,180,015	3	33	7,075	.005
O'Brien	26,356,610	4	53	12,000	.002
Osceola	10,475,117	13	212	23,850	.021

Continued on next page

Table XVII (Cont'd)

County	Risk in force	No. of losses	Amt. of damage	Building insurance	Loss/ $1000 risk
Page	$4,891,134	2	$ 24	$ 8,000	$.005
Palo Alto	13,185,382	3	20	6,500	.002
Plymouth	18,544,276	19	589	29,950	.032
Pocahontas	17,494,574	40	647	106,275	.037
Polk	6,584,741	15	500	31,200	.076
Pottawat'mie	22,547,371	149	2,217	219,550	.098
Poweshiek	12,523,003	1	9	2,000	.001
Ringgold	1,835,353	13	248	12,100	.135
Sac	16,613,631	44	1,229	98,750	.074
Scott	3,468,519	0	0	0	.000
Shelby	12,993,433	10	115	22,150	.009
Sioux	25,957,704	131	1,979	243,460	.076
Story	4,352,423	1	6	2,000	.001
Tama	10,161,599	1	3	2,000	.000
Taylor	3,814,670	1	6	2,500	.002
Union	1,030,253	5	100	11,300	.097
Van Buren	2,004,020	1	35	1,800	.017
Wapello	1,075,490	1	7	3,000	.007
Warren	3,237,232	15	179	23,100	.055
Washington	1,319,450	2	30	17,650	.023
Wayne	1,777,974	23	333	26,450	.187
Webster	18,636,417	5	85	11,000	.005
Winnebago	13,784,631	5	31	5,500	.002
Winneshiek	14,573,381	47	708	66,850	.049
Woodbury	5,851,553	19	660	35,250	.113
Worth	14,136,897	8	350	12,100	.025
Wright	13,283,655	7	79	14,200	.006
Total	879,345,997	1,836	42,449	3,107,385	.068

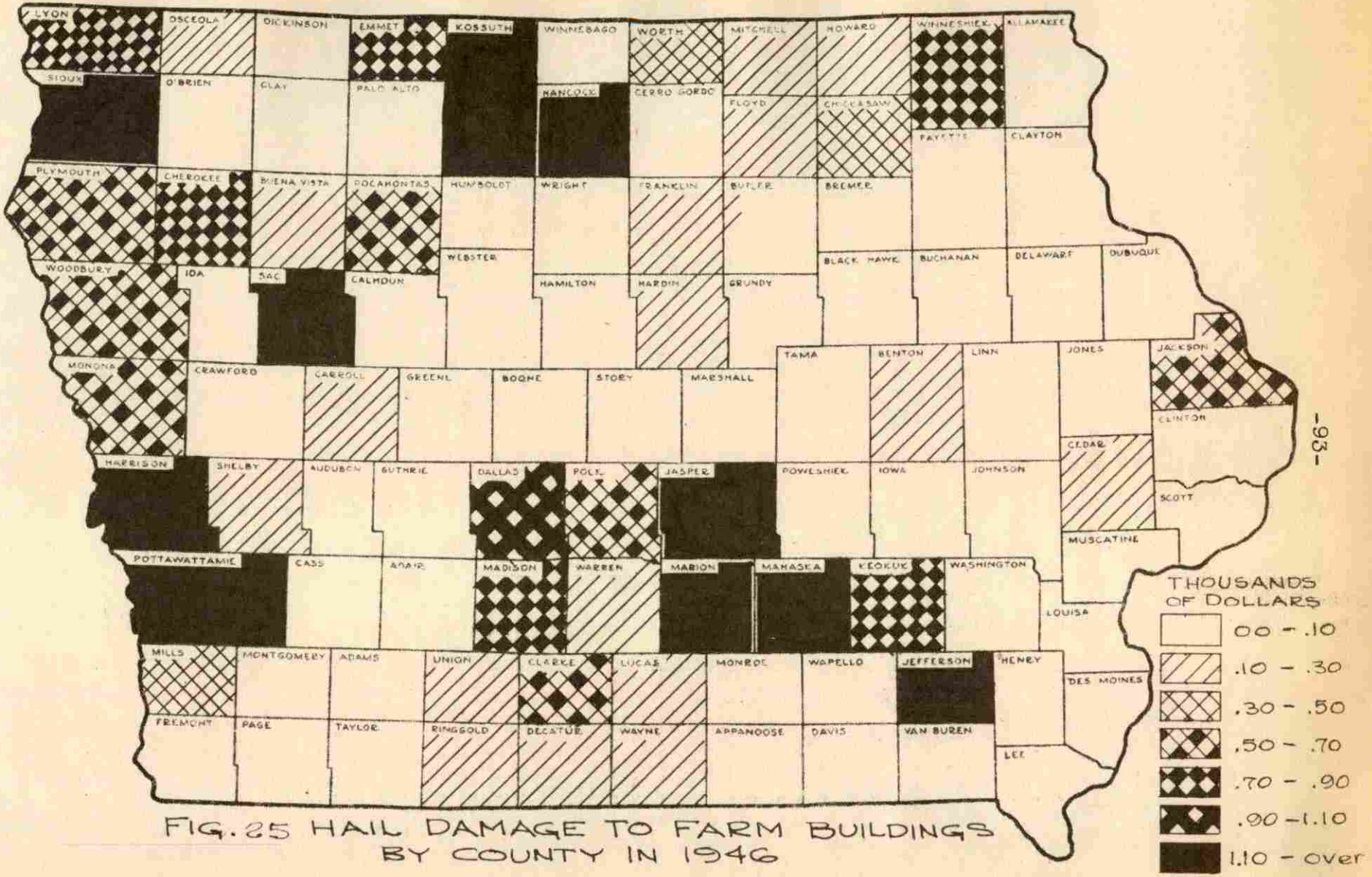

FIG. 25 HAIL DAMAGE TO FARM BUILDINGS BY COUNTY IN 1946

Table XVIII

DISTRIBUTION OF WIND DAMAGE TO IOWA FARM BUILDINGS BY MONTH IN 1946

Month	Building insurance	Policy insurance	Total damage	Total number damaged	Total no. of claims	Total hail damage	No. of hail losses
January	$ 49,325	$ 160,880	$ 720	36	33	$ 10	2
February	550,745	1,658,815	8,903	318	294	384	4
March	162,300	512,820	1,997	106	94	46	2
April	5,295,460	17,453,696	76,687	3,254	2,761	1,617	85
May	899,060	2,080,129	31,003	632	416	4,344	183
June	4,475,488	11,675,983	173,858	3,507	2,076	27,652	1,125
July	680,290	1,814,075	20,023	482	310	3,102	193
August	1,485,445	4,884,007	60,069	1,137	817	4,383	170
September	689,750	2,185,925	18,582	546	373	1,783	115
October	231,805	952,895	4,530	160	144	36	3
November	76,750	348,145	1,375	55	52	16	2
December	36,450	111,225	647	19	19	5	1
Total	13,632,868	43,838,595	398,424	10,252	7,389	43,378	1,885

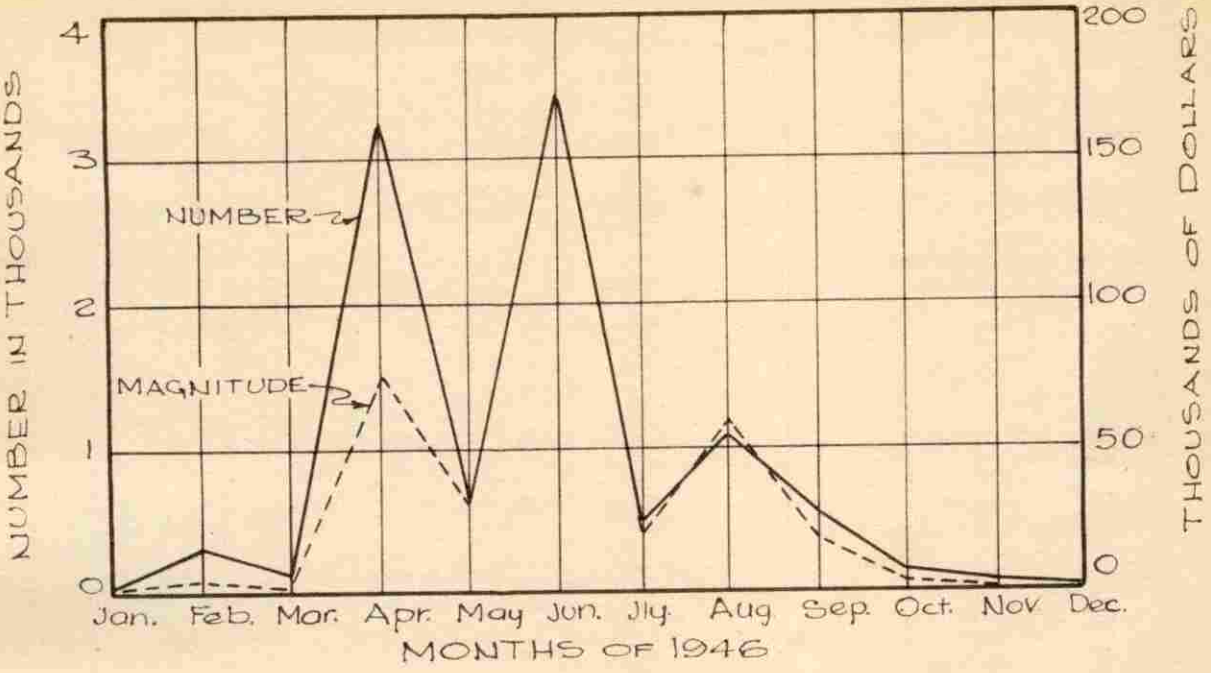

Fig 26 WIND DAMAGE TO FARM BUILDINGS BY MONTH

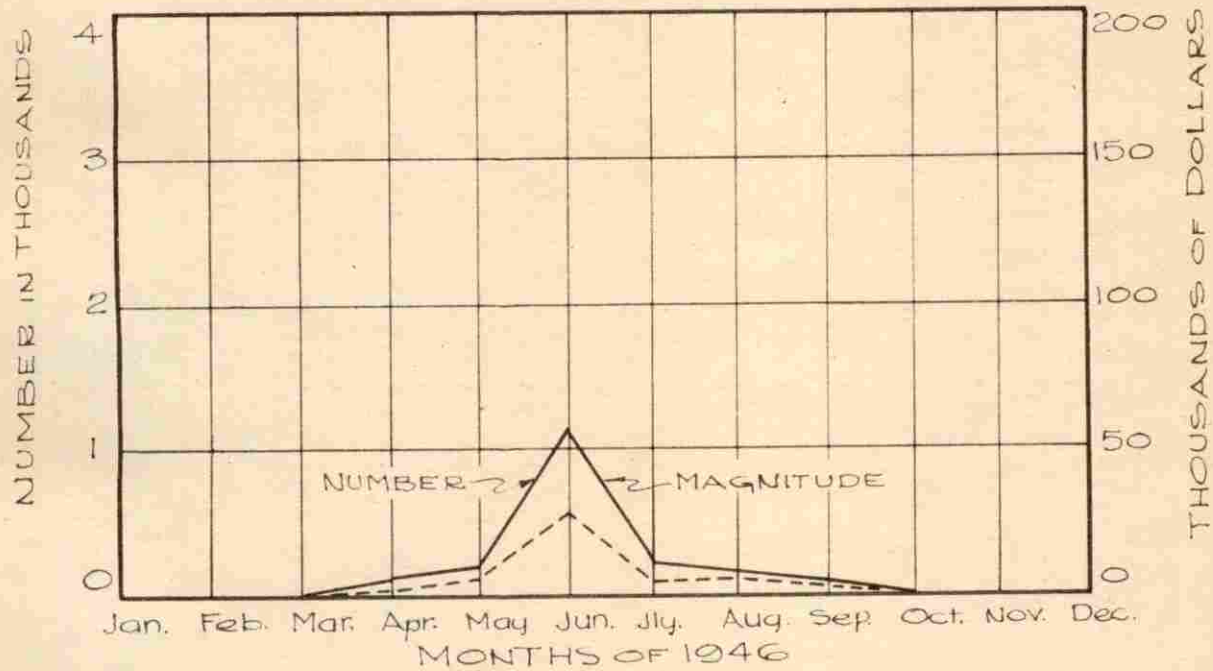

Fig. 27 HAIL DAMAGE TO FARM BUILDINGS BY MONTH

noted that in 1946 hail damage reached a peak in June, over one thousand hail damages being reported for that month. In comparing hail damage with damage by all causes represented in Figure 26, it is seen that the total magnitude for hail damage is low. As brought out previously in Figure 12, only 11.8 per cent of the damage is due to hail although 20.8 per cent of the damages are a result of hail. This is due to the nature of hail damage. There are no large hail damages running into thousands of dollars for one damage as there frequently are in demolition of buildings by wind.

Wind Damage by Month

Distribution by magnitude and number

Most of the wind damage to Iowa farm buildings occurs during the summer months. The distribution of wind damage for 1946 given in Table XVIII and illustrated graphically in Figure 26 shows two nearly equal peaks in number of damages and only one major peak in magnitude of damages. The peak month for both damage and number of damages was June. The total amount of damage for June was $173,858.00, involving 3,507 damages. The damage was caused by a number of wind and hail storms throughout the state.

In April, during which there were nearly as many damages reported to the Association as in June, there was only

$76,687.00 of damage recorded. This distinctly brings out the fact that April damages varied from the June damages in magnitude. The April damages, on the average, were only 47.6 per cent as large as the June damages.

In contrast to the June damage, the April damage was largely due to one general statewide windstorm, which occurred on April 3 and 4. This one storm accounted for 3,228 claims which was 31.5 per cent of all the damages recorded for 1946. The damage, however, amounted to only 18.87 per cent of the total. The difference in magnitude of damages within a period of two months is accounted for by the difference in the type of windstorm causing the damages. Analysis of the damage resulting from the April 3 and 4 storm is taken up in the following section of this document.

Distribution of insurance coverage by month

In the scales chosen for Figures 28 and 29 it is apparent that in the month of June the peaks for both the damage and number of damages exceeded the peak of the insurance coverage. The total insurance coverage on buildings damaged in the April windstorms was higher than it was for June by $819,972.00, even though, as brought out in Figure 28, the damage and number of damages were less. This shows not only a differentiation in the type and magnitude of damage, but a difference in the type of building damaged. This particular comparison

shows that the buildings damaged in April were higher valued buildings than those in June by $351.00 each.

It cannot be said that a few expensive buildings were damaged to great extent to account for this high building insurance average in April, because, as brought out, the average amount of each damage was quite low as compared to the other months. Due to the high insurance coverage of buildings damaged in April and the large number of buildings with comparatively little damage suffered, it is illustrated in Figures 28 and 29 that the peak for the number of damages recorded exceeds the peak for insurance coverage, while the peak for the magnitude of loss falls below it. In all other months except June, it is noted that the graphical representation of both the damage and number of damages exceeds that for building insurance coverage.

Average annual wind velocity by month

As determined from data obtained by the state Weather Bureau (13), April is the windiest month of the year in Iowa. The average hourly wind velocity by month was taken for a period of twenty years from 1927 to 1946 and listed in Table XIX and from this the average hourly velocity per month for the twenty-year period was determined and plotted in Figure 30. The average annual wind velocity for the twenty-year period was 8.5 miles per hour. The spring is shown as the

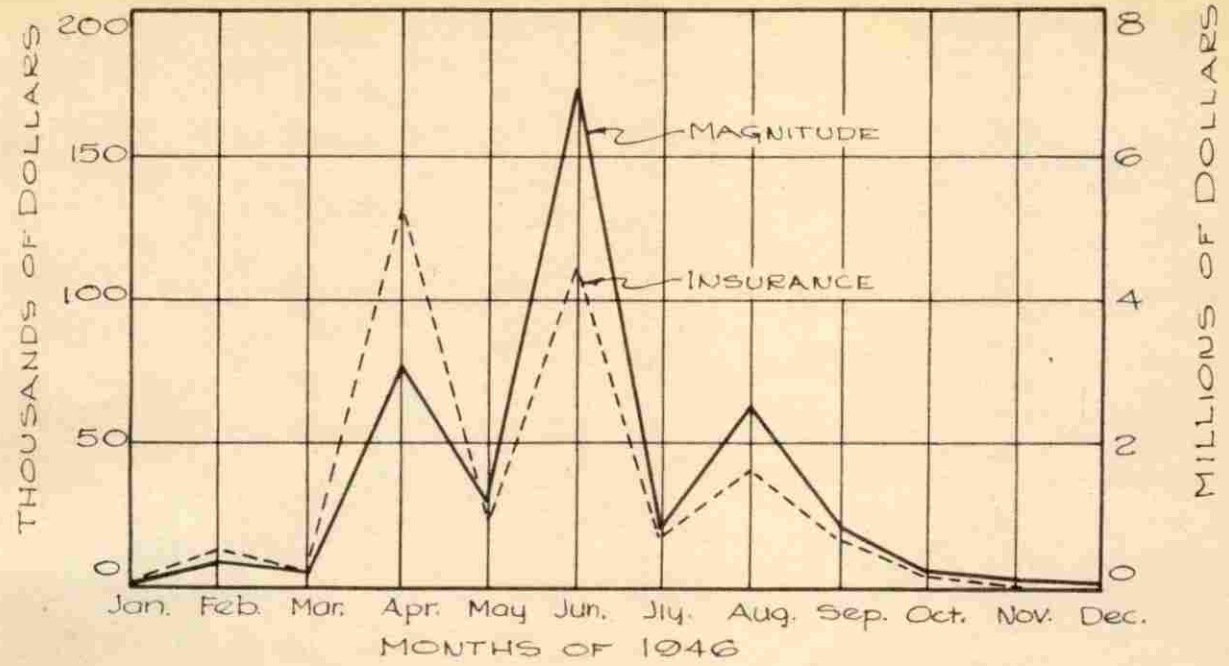

Fig. 28 WIND DAMAGE AND INSURANCE ON FARM BUILDINGS BY MONTH

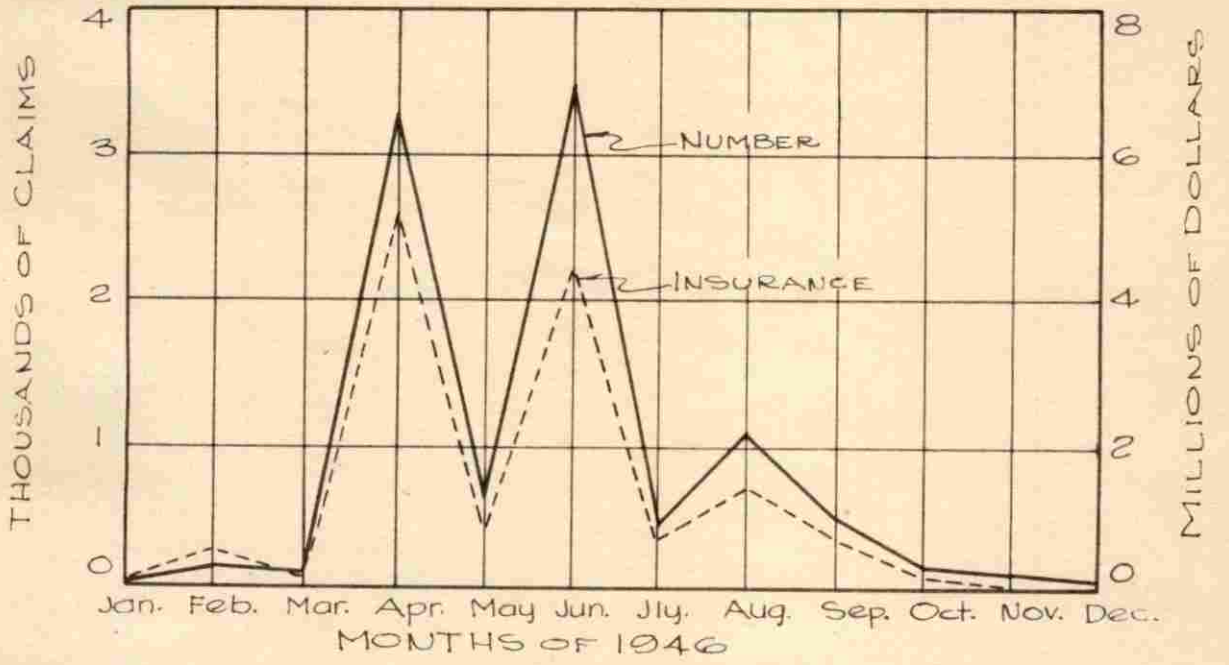

Fig. 29 DAMAGE CLAIMS AND INSURANCE ON FARM BUILDINGS BY MONTH

Table XIX

AVERAGE HOURLY WIND VELOCITY BY MONTH IN IOWA
FROM 1927 TO 1946

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1927	8.4	8.2	8.8	9.6	9.7	7.8	6.3	5.2	6.5	6.7	8.4	9.3
1928	7.5	8.0	7.5	9.1	6.7	6.5	5.4	6.1	6.1	6.8	8.0	6.9
1929	8.1	6.8	8.7	8.9	7.4	6.9	5.8	5.6	6.8	7.3	8.1	7.9
1930	8.1	8.2	10.7	8.4	9.1	7.5	6.3	5.1	6.9	7.3	9.1	7.1
1931	7.5	6.7	8.9	7.5	7.8	7.2	6.3	5.7	6.9	7.8	7.7	7.5
1932	9.1	9.1	10.8	10.0	9.0	6.9	7.8	7.6	7.0	9.2	9.7	8.9
1933	9.7	10.6	9.9	10.3	9.4	8.2	7.4	7.0	8.5	8.8	10.2	8.7
1934	9.2	9.8	10.3	10.8	9.6	8.6	8.3	7.6	8.4	8.8	9.3	9.3
1935	9.5	9.4	10.5	10.5	8.7	8.4	7.4	7.3	7.6	8.2	9.1	9.1
1936	8.3	9.6	10.6	9.8	8.7	8.5	7.5	7.8	7.9	8.6	9.7	8.8
1937	9.9	10.8	8.8	10.7	8.9	8.1	6.8	7.4	7.7	7.9	9.7	9.1
1938	9.5	9.4	10.1	11.0	8.9	8.3	6.9	7.8	6.8	8.2	9.6	8.9
1939	8.9	10.7	9.5	10.4	8.4	8.4	7.3	6.8	8.5	9.3	7.4	8.4
1940	9.0	8.7	9.5	10.5	8.9	8.7	8.0	6.8	7.0	7.4	9.4	8.3
1941	8.6	9.2	9.0	9.4	8.6	10.3	6.9	7.3	9.1	7.6	9.0	9.4
1942	9.2	8.8	11.1	10.7	9.7	8.2	7.3	7.3	8.0	7.8	10.3	8.9
1943	10.0	10.5	11.5	11.4	8.1	8.9	6.8	7.4	7.8	7.7	8.3	9.1
1944	8.7	9.1	11.4	10.4	8.8	9.8	7.6	8.0	7.4	7.4	9.6	9.1
1945	8.0	8.9	10.1	12.0	10.3	8.3	7.5	7.5	8.7	8.3	10.4	9.5
1946												
Av	8.4	8.6	9.4	9.6	8.3	7.8	6.7	6.6	7.2	7.6	8.7	8.2

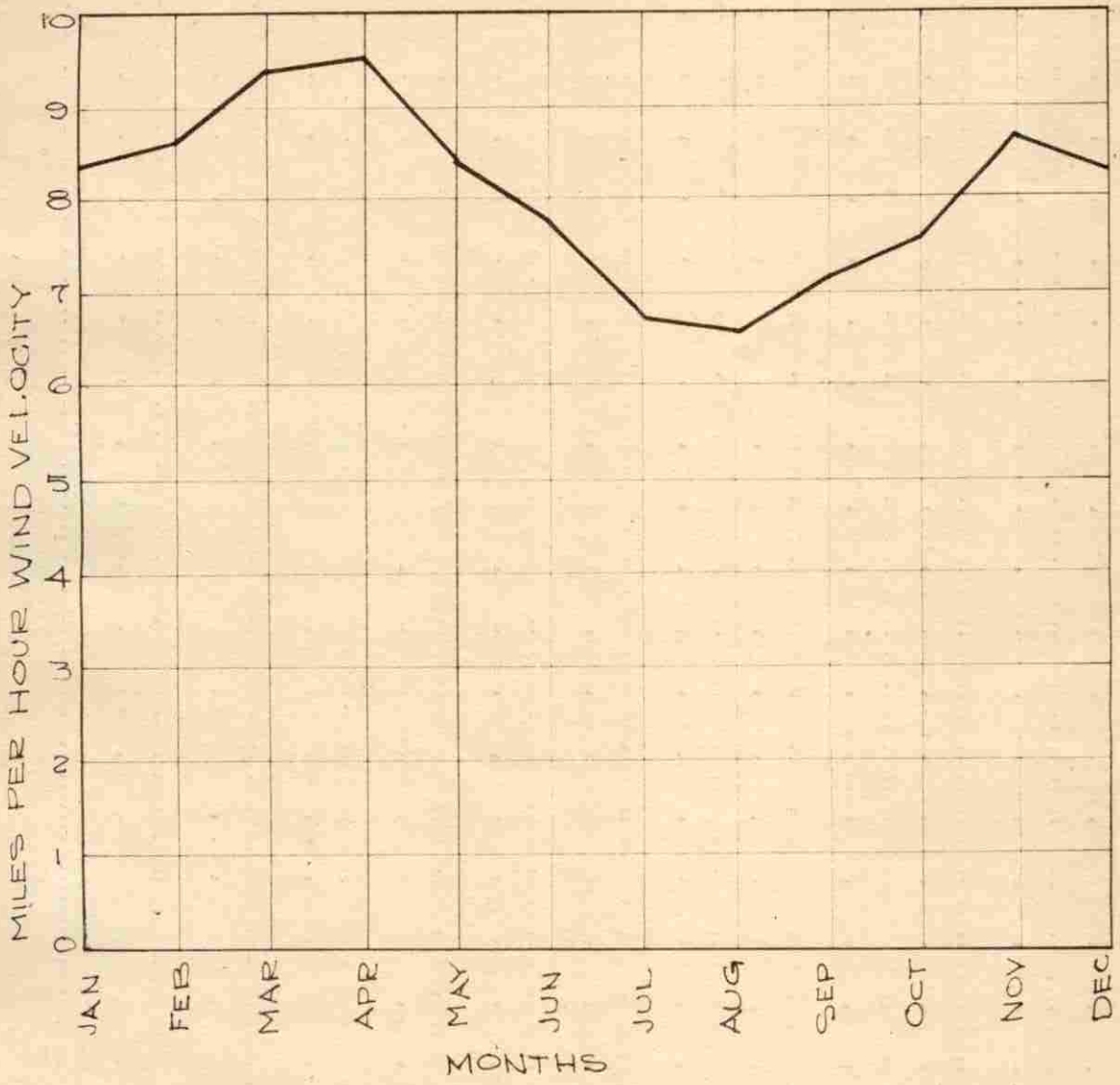

FIG. 30 AVERAGE HOURLY WIND VELOCITY BY MONTH IN IOWA FROM 1927-1946

windy season of the year and the late summer and fall with much less wind. August is shown as having the least wind with an average hourly wind velocity of 6.6 miles per hour.

This curve cannot, however, be correlated with amount of wind damage by month because August, for example, could easily be the month with the most frequent short-lived destructive windstorms and still it might not show up in the average hourly rates. On the other hand, March and April may have a lot of wind of 15 to 20 miles per hour velocity but not of a destructive nature.

Wind Damage by Windstorm of April 3 and 4, 1946

Distribution of damage

Figure 31 represents the wind damage by county graphically and shows that the windstorm of April 3 and 4 was fairly general throughout the state, causing somewhat more intense building destruction in the northern and western sections than in the southeast section. Table XX lists the loss and number of damages numerically by county along with the risk in force, in order that the loss ratio could be easily calculated. From the state Weather Bureau recordings (13), the maximum wind velocities throughout Iowa on April 3 and 4 were obtained. Data from nine Weather Stations were available. There were numerous reported gust velocities of 60

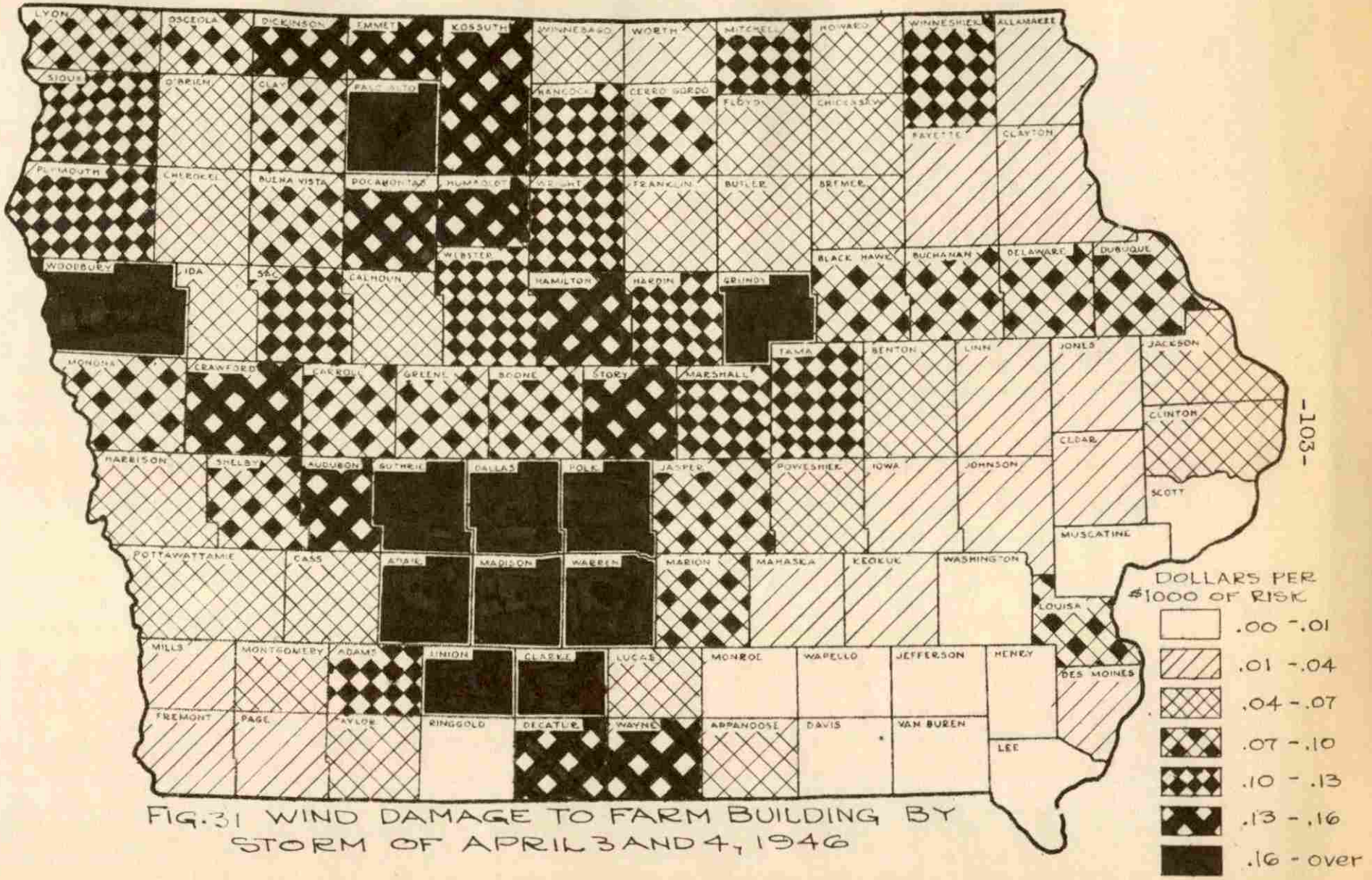

FIG. 31 WIND DAMAGE TO FARM BUILDING BY STORM OF APRIL 3 AND 4, 1946

Table XX

DISTRIBUTION OF WIND DAMAGE BY COUNTIES
BY STORM OF APRIL 3-4, 1946

County	Risk in force	No. of losses	Amt. of damage	Building insurance	Loss/ $1000 risk
Adair	$ 5,060,546	28	$1,027	$ 48,475	$.203
Adams	3,386,377	23	372	44,100	.110
Allamakee	6,821,795	9	97	9,100	.014
Appanoose	976,450	5	50	4,200	.051
Audubon	8,586,926	57	1,181	61,950	.138
Benton	8,535,461	14	455	16,450	.053
Black Hawk	8,204,944	44	712	78,350	.087
Boone	10,751,445	59	796	109,040	.074
Bremer	9,418,650	21	475	31,800	.050
Buchanan	4,892,010	13	383	14,900	.078
Buena Vista	19,145,258	89	1,438	129,080	.075
Butler	11,362,012	27	563	43,700	.050
Calhoun	9,953,171	53	624	97,250	.063
Carroll	5,707,022	20	449	36,450	.079
Cass	6,550,824	22	301	29,050	.046
Cedar	7,200,664	8	140	10,950	.019
Cerro Gordo	15,552,507	35	1,197	45,625	.077
Cherokee	13,407,244	42	881	48,200	.066
Chickasaw	10,327,941	34	748	58,650	.073
Clarke	440,430	5	153	8,025	.348
Clay	20,588,930	71	1,789	115,925	.087
Clayton	15,268,331	20	221	46,300	.014
Clinton	6,099,440	8	348	15,300	.057
Crawford	952,325	4	126	7,300	.132
Dallas	8,987,640	93	2,177	150,825	.242
Davis	191,195	0	0	0	.000
Decatur	667,410	1	84	1,800	.126
Delaware	7,388,410	12	672	10,500	.091
Des Moines	3,790,600	6	45	11,700	.012
Dickinson	10,097,631	32	1,303	42,250	.129

Continued on next page

Table XX (Cont'd)

County	Risk in force	No. of losses	Amt. of damage	Building insurance	Loss/ $1000 risk
Dubuque	$ 2,877,730	6	$ 239	$ 18,600	$.083
Emmet	9,109,653	50	1,193	54,750	.131
Fayette	13,269,239	12	234	18,600	.018
Floyd	9,920,606	21	672	31,400	.068
Franklin	18,638,040	51	1,151	83,550	.062
Fremont	2,644,202	5	66	5,800	.025
Greene	11,539,187	62	944	106,490	.082
Grundy	12,919,240	78	2,313	131,050	.179
Guthrie	5,730,228	50	1,025	78,025	.179
Hamilton	7,522,104	43	1,093	86,650	.145
Hancock	17,355,312	56	1,980	69,375	.114
Hardin	8,209,300	85	1,847	119,150	.225
Harrison	14,669,415	16	447	17,500	.030
Henry	8,129,738	2	27	2,650	.003
Howard	3,430,216	14	403	16,275	.117
Humboldt	13,815,301	41	1,117	50,940	.081
Ida	5,626,498	10	231	22,800	.041
Iowa	7,905,063	10	96	19,500	.012
Jackson	6,444,167	12	255	20,750	.040
Jasper	13,456,555	82	1,153	167,205	.086
Jefferson	3,758,610	2	26	4,500	.007
Johnson	7,463,578	9	167	9,450	.022
Jones	6,807,524	14	227	25,700	.033
Keokuk	7,137,748	11	214	30,000	.030
Kossuth	23,609,932	109	3,388	183,960	.143
Lee	1,419,600	0	0	0	.000
Linn	9,177,469	14	343	22,400	.037
Louisa	2,434,025	2	214	3,000	.088
Lucas	2,430,185	7	120	11,450	.049
Lyon	16,387,369	49	1,399	75,050	.085
Madison	5,864,070	31	1,096	48,800	.187
Mahaska	4,035,154	8	90	16,350	.022
Marion	2,960,894	9	210	13,500	.071
Marshall	10,696,566	48	1,167	91,700	.109
Mills	5,439,436	6	182	7,425	.034

Continued on next page

Table XX (Cont'd)

County	Risk in force	No. of losses	Amt. of damage	Building insurance	Loss/ $1000 risk
Mitchell	$12,593,923	23	$1,508	$ 34,000	$.120
Monona	5,584,284	28	539	31,600	.096
Monroe	117,275	0	0	0	.000
Montgomery	8,212,462	9	324	15,575	.039
Muscatine	7,180,015	3	29	5,700	.004
O'Brien	26,356,610	75	1,567	139,850	.059
Osceola	10,475,117	42	809	51,925	.077
Page	4,891,134	9	150	17,400	.031
Palo Alto	13,185,382	80	2,170	116,340	.165
Plymouth	18,544,276	75	2,062	103,200	.111
Pocahontas	17,494,574	125	2,589	254,075	.148
Polk	6,584,741	51	1,148	104,525	.175
Pottawat'mie	22,547,371	69	1,455	119,300	.064
Poweshiek	12,523,003	42	751	79,450	.060
Ringgold	1,835,353	4	11	2,050	.001
Sac	16,613,631	75	1,878	163,675	.113
Scott	3,468,519	0	0	0	.003
Shelby	12,993,433	56	1,196	92,100	.092
Sioux	25,957,704	108	2,709	143,725	.104
Story	4,352,423	30	672	56,930	.154
Tama	10,161,599	74	1,086	109,530	.107
Taylor	3,814,670	17	250	18,900	.065
Union	1,030,253	14	294	21,600	.286
Van Buren	2,004,020	0	0	0	.000
Wapello	1,075,490	1	5	800	.005
Warren	3,237,232	23	691	40,450	.214
Washington	1,319,450	0	0	0	.000
Wayne	1,777,974	5	236	8,700	.133
Webster	18,636,417	102	2,121	187,475	.114
Winnebago	13,784,631	25	610	37,825	.044
Winneshiek	14,573,381	40	1,528	67,425	.104
Woodbury	5,851,553	25	968	34,750	.165
Worth	14,136,897	23	341	44,050	.024
Wright	13,283,655	50	1,343	87,600	.101
Total	879,345,997	3,183	75,176	5,182,115	.084

miles per hour on April 3 and a few up to 70 miles per hour, with the maximum recorded gust velocity being 72 miles per hour at the Des Moines station at 4 p.m., April 3. It is apparent from these data that there were no winds of tornado character or velocity; rather, they were high winds of cyclonic nature. "In general," as described by Giese (11), "two types of storms cause damage to buildings. The first is the tornado, a very rapid whirl of small diameter; the second is the cyclone or hurricane, which is of such large diameter that it appears to be a straight wind."

Type of damage

In order to analyze the type of wind damage to farm buildings, resulting from a storm of known type and velocity, a complete study was made of the 3,183 damages and $75,176.00 of damage resulting from the storm of April 3 and 4. Table XX lists the 2,936 damages and $69,779.00 damage resulting from destruction of farm buildings by the April 3 and 4 storm. The loss and number of damages are broken down by type of building and damage. To obtain a correlation between types of damage resulting from the April 3 and 4 storm and those resulting from all storms during 1946, the per cent of total damage was plotted for each type of damage and illustrated graphically in Figure 32. The greatest difference occurred in damage from demolition of buildings. Only 8.7

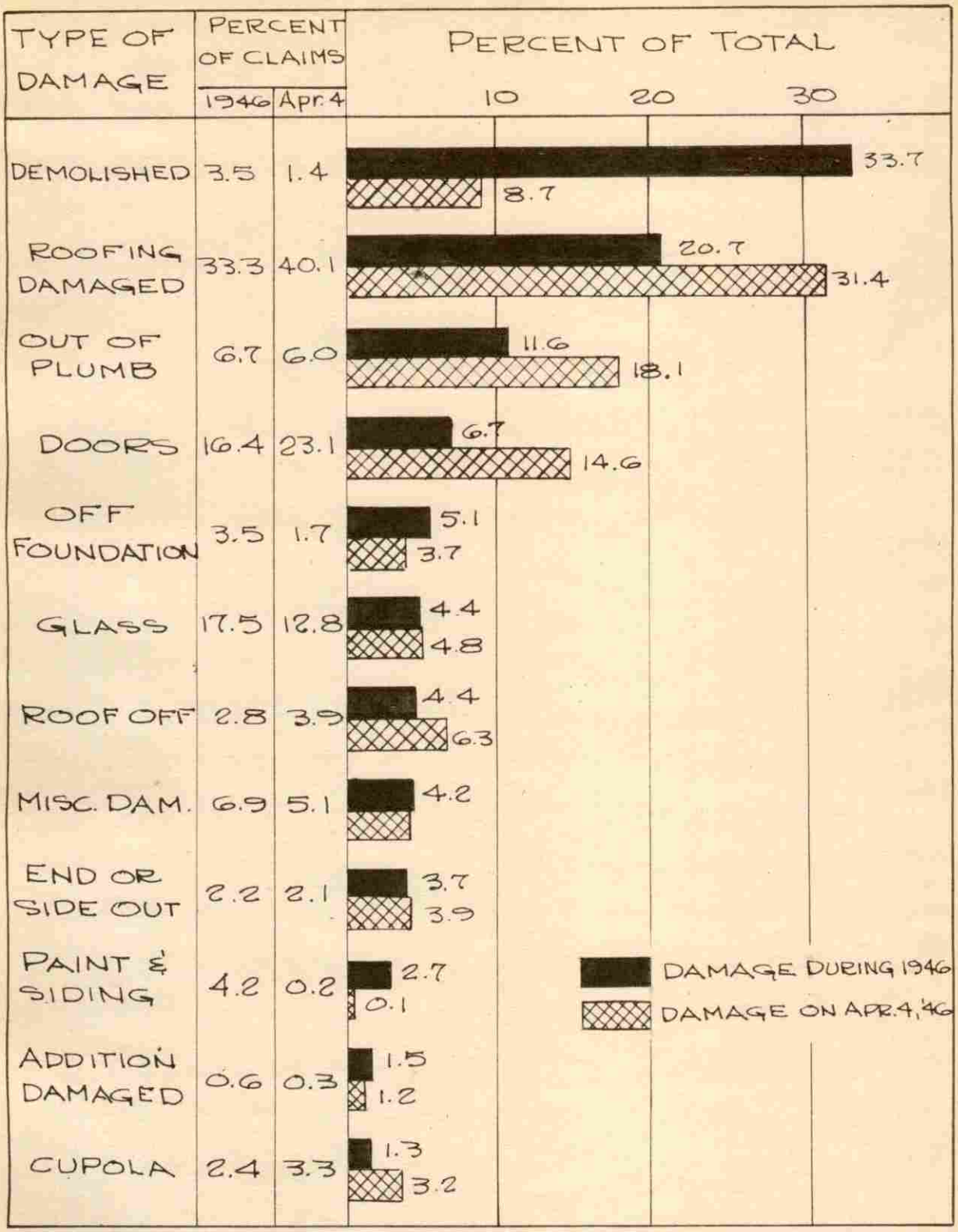

FIG. 32 WIND LOSS TO IOWA FARM BUILDINGS, TOTAL FOR 1946 COMPARED WITH APR. 4, STORM

per cent of the wind damage on April 3 and 4 was due to demolition of buildings as compared to 33.7 per cent for the year 1946. In first place in damage for the April storm appears roofing damage, with 31.4 per cent of the total as compared to 20.7 per cent for the year. Buildings out of plumb and doors damaged also showed a much higher per cent of loss for the April storm than they did for the total year.

It appears from the type of damage resulting from the April 3 and 4 storm that it was not, generally speaking, of a building demolition velocity; rather, a type reaching to a great number of the minor weaknesses, such as roofing, doors and wind bracing. It was a storm of sufficient velocity to over-stress buildings having insufficient bracing, thereby blowing them out of plumb; to catch and swing off from their hinges, many doors, sliding and otherwise; and to rip off many shingles of poor quality or of improper application.

Type of property damaged

To illustrate graphically the type of property damaged by the April 3 and 4 storm, Figure 33 was prepared. In April, 65.3 per cent of the damage and 65.8 per cent of the damages were on barns and dwellings, while for the year 1946 62.0 per cent of the damage and 59.9 per cent of the damages were accounted for by those two types of buildings. This

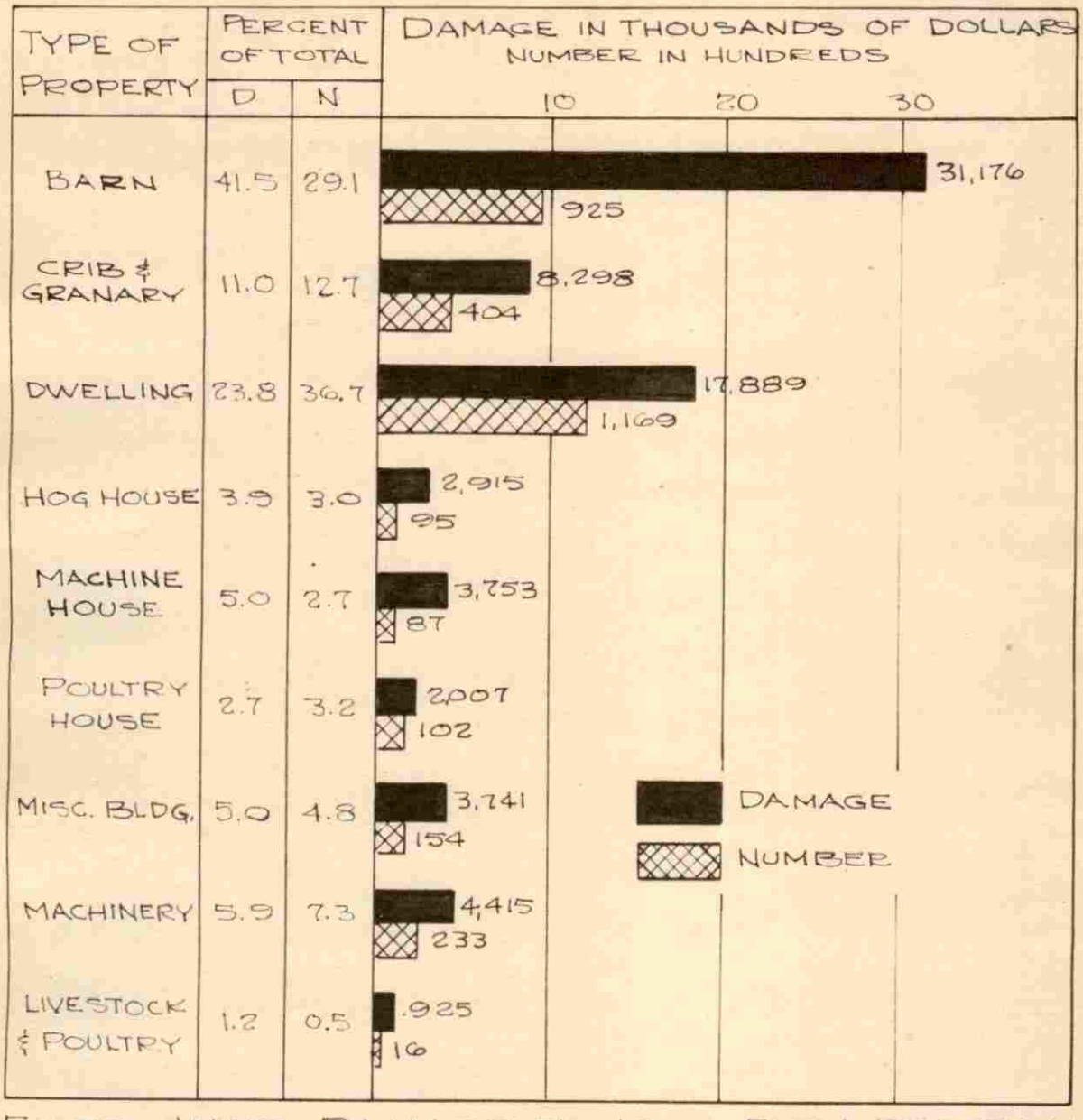

FIG. 33 WIND DAMAGE TO IOWA FARM PROPERTY BY STORM OF APRIL 3 & 4, 1946

Table XXI

WIND DAMAGE TO IOWA FARM BUILDINGS BY STORM OF APRIL 3-4, 1946

		Barn	Crib	Dwell	Hog house	Mach. house	Poult house	Misc. bldg.	Total
Demolished	D:	1405	405		700	1940	978	635	6063
	N:	9	4		2	10	9	7	41
Roofing	D:	6127	1912	11850	443	260	310	961	21863
	N:	278	99	667	35	20	30	46	1175
Out of plumb	D:	10386	1222		446	266	44	267	12631
	N:	120	24		13	8	1	11	177
Doors	D:	4280	3503	1502	25	327	28	516	10181
	N:	251	223	131	2	26	3	40	676
Misc. damage	D:	439	36	549	165	31	120	306	1646
	N:	32	3	31	10	2	5	10	93
Off foundation	D:	1640	176		75	428	99	192	2610
	N:	17	8		2	7	8	9	51
Glass	D:	304		2126	121		210	544	3305
	N:	43		264	17		33	19	376
Roof off	D:	2720	541	199	579	236	96	37	4408
	N:	53	23	14	7	8	7	3	115
End or side out	D:	1388	306		351	265	122	283	2715
	N:	32	4		6	6	6	9	63
Paint damaged	D:	6	12	63	10				91
	N:	1	1	4	1				7
Addition	D:	450		408					858
	N:	6		2					8
Cupola	D:	2031	185						2216
	N:	83	15						98
Chimney	D:			522					522
	N:			28					28
Porch	D:			640					640
	N:			28					28
Total	D:	31176	8298	17889	2915	3753	2007	3741	69779
	N:	925	404	1169	95	87	102	154	2936

D - Damage N - Number

shows a slight increase in per cent of total for damage to these two farm buildings which are by far the two highest valued ones on the average Iowa farmstead. This would indicate some evidence of damage to higher valued buildings or those of higher insurance coverage. To explain more thoroughly the fact that the buildings damaged by the April 3 and 4 storm had a noted higher insurance coverage than the average for the year 1946, the following is offered: Damage to roofing and doors may result on any type of building regardless of how expensive or well built otherwise. The doors in many cases may be left open and through no fault of the building, be blown off. The roofing material may be of poor quality or not applied correctly, thereby allowing a roof damage, although it may be on a five or ten thousand dollar building. A building design like a chain is no better than its weakest part, and the full value of a building will not be realized if a poor roofing is applied only to deteriorate soon and allow rain to enter and damage the contents.

Magnitude of building damage

The average magnitude of the damages recorded from the April 3 and 4 storm was $23.45, while for the year it was $38.90. That indicates that the average damage caused by the storm was only 60.4 per cent of the average amount for all

damages for 1946. Fewer demolished buildings was one reason for the smaller damages. As indicated in Figure 34, the average amount of the damages on dwellings was only $15.35, while for 1946 it was $20.70.

This decrease in magnitude of damages on the dwelling cannot be laid to fewer demolished buildings though, because there was only one such case in 1946. This brings out the point that the average damage to the roofing, doors, and other items by the April storm was smaller in magnitude than for the year.

In general, the storm of April 3 and 4, 1946 was of a type which causes a great many minor losses, but few major ones. These are the types of losses that can be prevented in most cases through continued maintenance and proper upkeep of the buildings.

Wind Damage to Roofing Materials on Iowa Farm Structures

Introduction

The problem as the old proverb states, of keeping a roof over your head, is still a very imminent one with the farm operators of Iowa. Not only must they keep themselves sheltered, but they must also furnish satisfactory protection for their livestock, feed and machinery.

"The fundamental function of any roof," as given by the

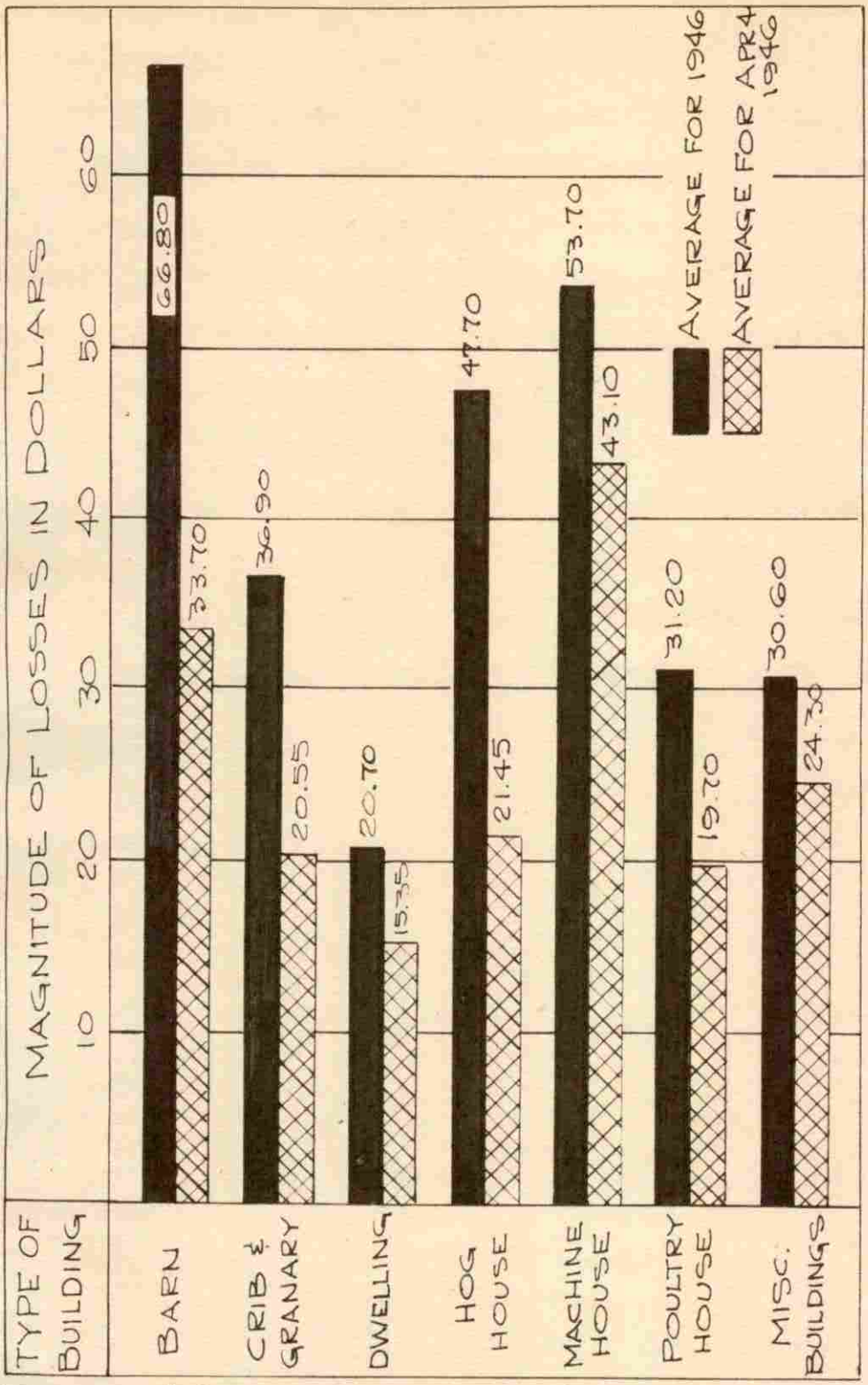

FIG. 34 WIND LOSSES TO IOWA FARM BUILDINGS FOR 1946 COMPARED WITH APR. 4, 1946

National Bureau of Standards (16), "is to protect the interior of a structure, its contents, and occupants, from the weather." Properties most desired in roofing materials are, waterproofness, both initially and during long periods of exposure; weather resistance; appearance; fire resistance; ease of application; weight; and annual cost.

In order for a roof to retain waterproofness continuously, it must be kept in A-1 condition and this means resistance to weather. A wind or hail damaged roof will no longer protect the interior of the structure from the elements of weather. Internal damage to contents means added expenditure which can only be charged against an unsatisfactory roof.

Wind and hail damage

Damage claims in 1946 on farm structure covered by wind insurance policies underwritten by the Iowa Mutual Tornado Insurance Association amounted to $354,454.00. Of this amount, $337,494.00 was a result of the direct action of wind and hail. Only these two causes will be considered throughout this analysis on roofing damage. Other causes, such as flying debris, falling trees, and objects, inflicted some damage, but it was more of a mechanical nature and hence will not be correlated with damage from wind and hail acting directly.

The $337,494.00 damage to farm buildings resulting from

8,421 damages was segregated into fourteen main types of structural failures, and the magnitude of loss and number of damages for each type is listed in Table XXII. Figure 35 illustrates the same data graphically, showing percentages of total loss also. In magnitude of loss, damage to roofing ranks second only to demolition of buildings, and in number of claims it is the highest with 32.1 per cent of the total. This indicates that one out of every three claims received by the Association was a roofing damage and that one out of every five dollars of loss was accounted for by this type of structural failure.

As illustrated in Figure 35, the number of roofing damages exceeds by far the number for any other one of the eleven types of damage. Glass damages, which were next to roofing damages in number, accounted for over a thousand less claims than did roofing.

Magnitude of losses

The average amount of each roofing damage claim was $24.00 which is somewhat below the average of $40.20 for all types of wind and hail damages to farm structures in Iowa in 1946. The latter includes demolition of buildings which occasionally result in individual losses of several thousand dollars.

The smaller magnitude of the roofing material losses is

Table XXII

DAMAGE TO IOWA FARM BUILDINGS BY WIND AND HAIL IN 1946

		Barn	Crib	Dwelling	Hog house	Mach. house	Poult house	Misc. bldg.	Total
Demolished	D:	71313	13860	1200	10786	9279	6764	3960	117162
	N:	90	46	1	41	43	48	35	304
Roofing	D:	16135	4183	36220	2118	956	1554	3618	64784
	N:	647	213	1439	97	55	103	144	2698
Out of plumb	D:	30089	4387	651	1970	1985	844	837	40763
	N:	326	82	7	47	63	26	42	593
Doors	D:	10888	7893	2885	83	803	66	827	23445
	N:	601	465	254	6	60	11	65	1462
Off foundation	D:	9260	2787	60	1387	1787	1948	910	18139
	N:	73	55	1	36	35	67	38	305
Glass	D:	1349	0	9710	1030	0	939	2167	15195
	N:	168	0	1006	125	0	143	74	1516
Roof	D:	8615	1681	130	1266	1815	642	478	14627
	N:	106	39	10	15	20	13	10	213
End or side out	D:	8258	688	0	1498	703	867	336	12350
	N:	97	13	0	22	18	21	12	183
Paint damaged	D:	1941	673	6326	146	73	145	91	9395
	N:	76	36	206	15	7	13	10	363
Misc. damage	D:	1600	1098	2553	532	97	385	1247	7512
	N:	85	37	122	26	9	18	27	324
Addition	D:	4181	0	998	0	0	0	0	5179
	N:	40	0	11	0	0	0	0	51
Cupola	D:	4256	492	0	0	0	0	0	4748
	N:	186	29	0	0	0	0	0	215
Chimney	D:	0	0	2375	0	0	0	0	2375
	N:	0	0	121	0	0	0	0	121
Porch	D:	0	0	1820	0	0	0	0	1820
	N:	0	0	73	0	0	0	0	73
Total	D:	167885	37742	64928	20816	17498	14154	14471	337494
	N:	2495	1015	3251	430	310	463	457	8421

D - Damage N - Number

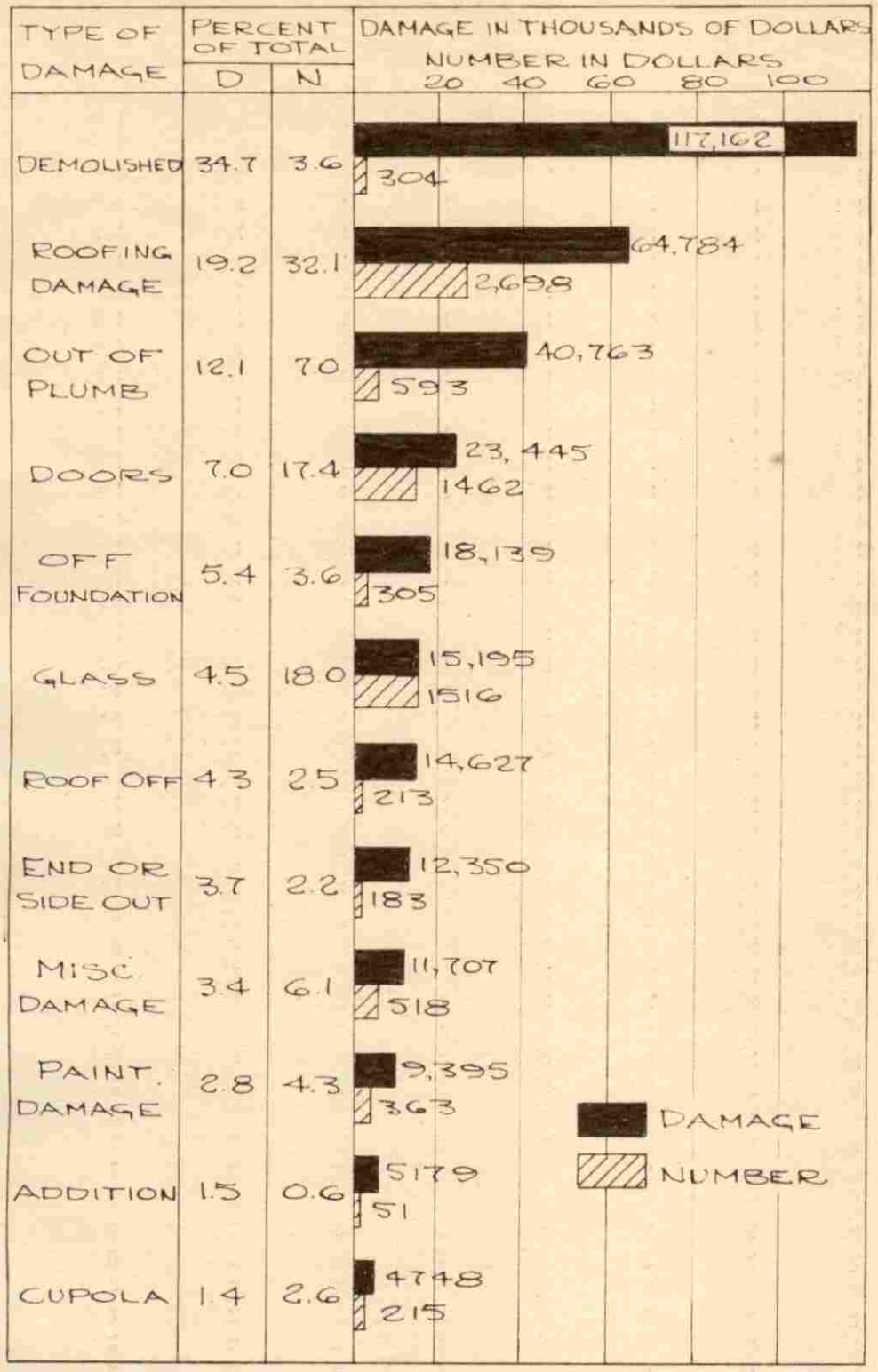

FIG.35 WIND AND HAIL DAMAGE TO FARM BUILDINGS IN IOWA

accounted for partly by the nature of the damage, usually, only patches of shingles or roofing material being damaged; and partly because the settlements of claims on roofing material losses are pro-rated in accordance with the age of the roofing material at the time of damage. The Association does not underwrite roll roofing of any type or quality and assumes only a pro-rated amount of the damage suffered by other types of roofing under twenty years of age. The Association set up twenty years as the insurable life of roofing materials, and holds to it very closely in the settlement of claims involving asphalt shingles.

Previous studies

A study similar to this one was made for the years 1930 to 1933. It was found at that time that roofing damage was of far less significance than it is today. Figure 36 illustrates the relative significance of damage to roofing for the period of years 1930-33 with that of 1946. It is shown that the damage resulting from the direct action of wind and hail has more than tripled since 1933 and the percentage of damages has more than doubled.

Roofing material on Iowa farm buildings

In tabulating the types of roofings on all the farm buildings which had wind damage claims submitted in 1946,

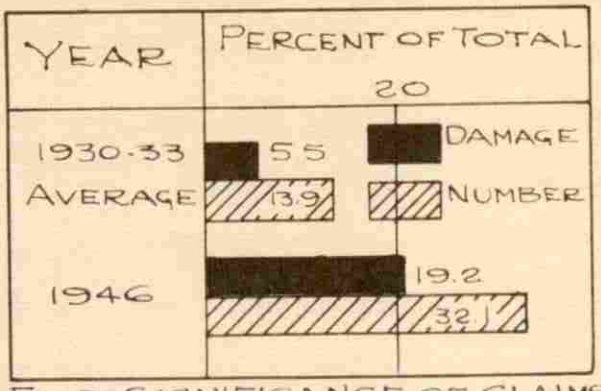

FIG 36 SIGNIFICANCE OF CLAIMS FOR ROOFING DAMAGE

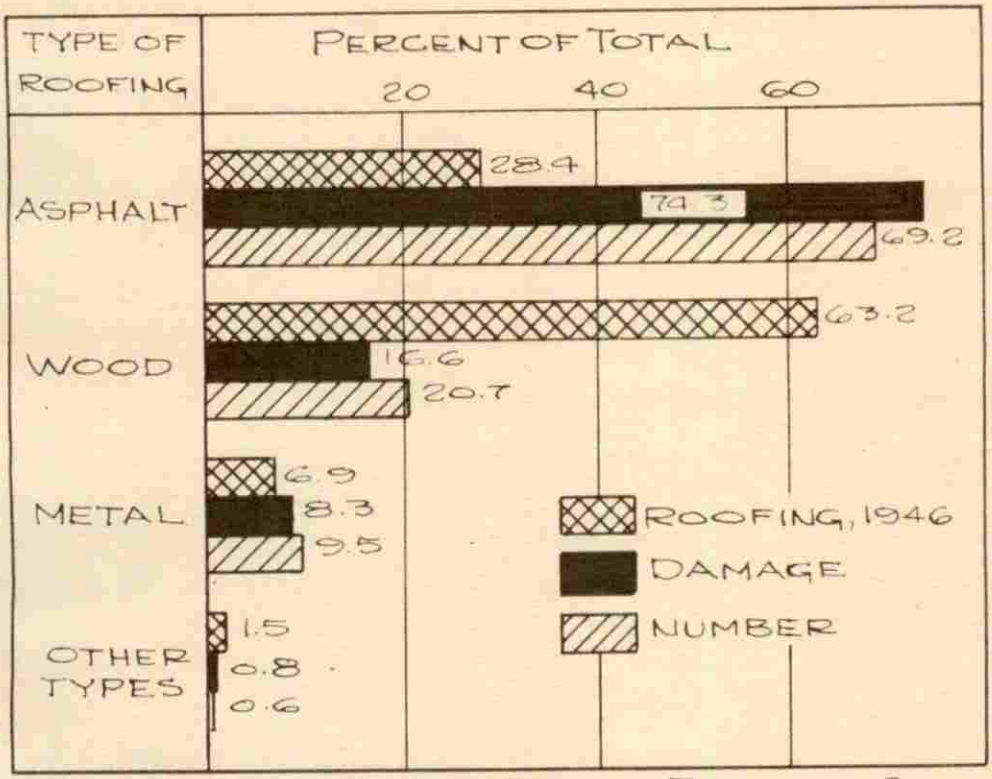

FIG. 37 ROOFING ON FARM BUILDINGS WITH DAMAGE BY TYPE

it was found that 28.4 per cent of the buildings were roofed with asphalt shingles (Figure 37), as compared to 63.2 per cent with wood. These percentages are on number of buildings only.

In Figure 38 the types of roofing found on the different farm buildings are given in percentage of the number of that type of building surveyed. The dwellings have a much higher per cent with asphalt shingle roofs than any of the other farm buildings. According to these data, 65 per cent of all buildings have asphalt shingles are dwellings. The service buildings of the farmstead had an average of about 13 per cent with asphalt shingles in 1946.

From a survey made by the American Zinc Institute (17) in 1941 and 1942, the average areas of the roofing on the various types of Iowa farm buildings was found to be as listed in Column 1 of Table XXIII.

From Table XXIII it is noted that only 10.90 squares out of a total of 64.80 squares on the average farmstead in Iowa had asphalt roofing on in 1946. This is 16.8 per cent of the total area as compared to 28.4 per cent by number. It is quite evident from these data that asphalt shingles are being applied to the smaller buildings of the farmstead.

Roofing material damage

Table XXIV lists the amount of damage and number of

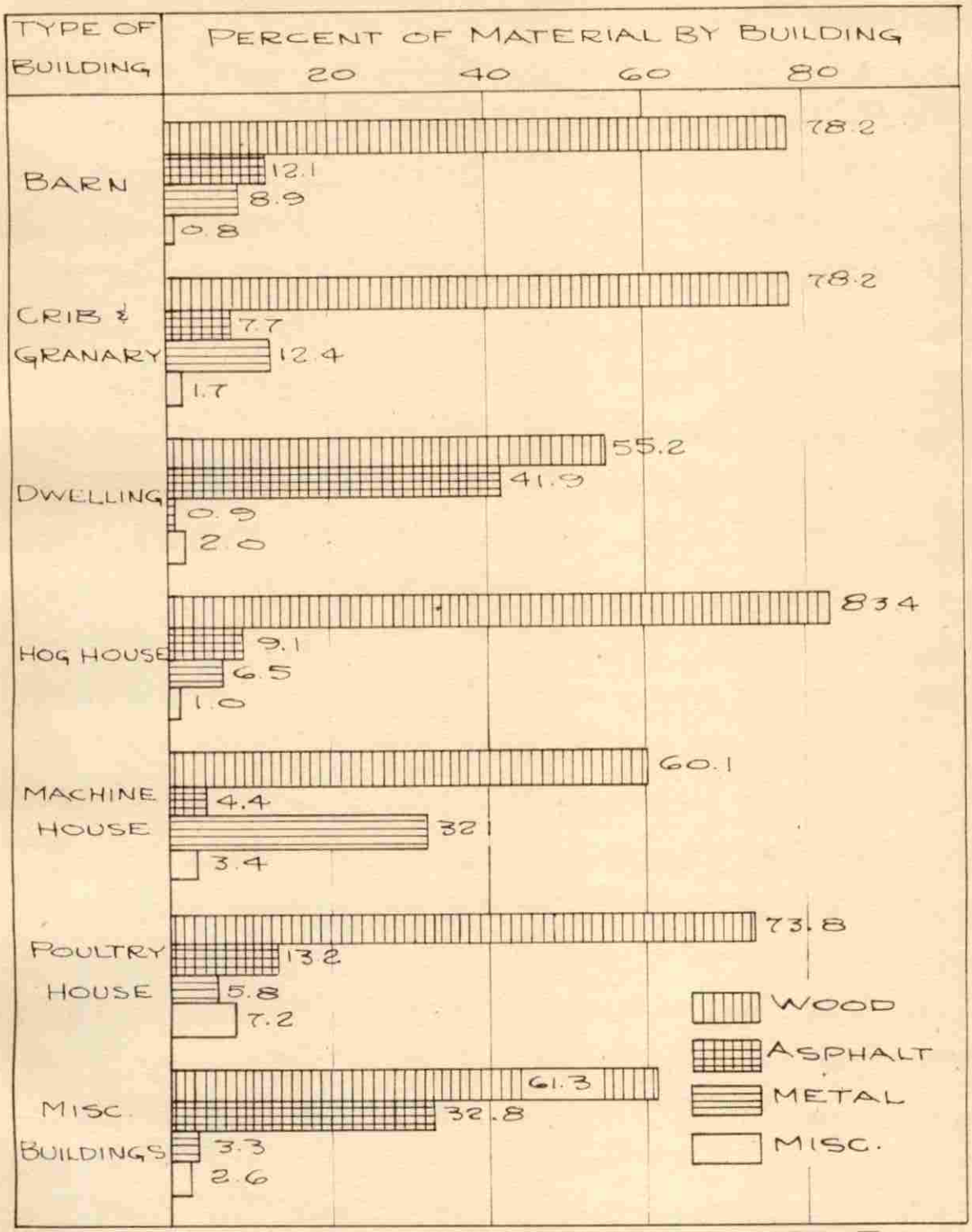

FIG. 38 ROOFING ON FARM BUILDINGS BY NUMBER OF ROOFS

Table XXIII

FARMSTEAD ROOFING AREA IN IOWA WITH AVERAGE PORTION OF ASPHALT AND WOOD SHINGLES IN 1946

Type of building	Av. area squares	Asphalt per cent of no.	Wood per cent of no.	Asphalt squares	Wood squares
Dwelling	11.60	41.9	55.2	4.86	6.4
Barns	24.30	12.1	78.2	2.94	19.0
Cribs and granary	5.96	7.7	78.2	.46	4.7
Hog house	8.21	9.1	83.4	.75	6.8
Poultry house	4.60	13.2	73.8	.61	3.4
Machine house	7.21	4.4	60.1	.32	4.3
Misc. bldg.	2.92	32.8	61.3	.96	1.8
Total	64.80			10.90	46.4

damages by type of roofing for each of the types of farm buildings. Figure 39 illustrates the losses by types of roofing material graphically. From Figure 39 it is noted that even though only 28.4 per cent of the number of farm buildings surveyed or 16.8 per cent by area were roofed with asphalt shingles, 74.3 per cent of the total damage to roofing was to this type. On the other hand, wood shingles accounted for 63.2 per cent of the number of roofs or 71.6 per cent by area and only 16.6 per cent of the damage.

Damage to all types of roofing is illustrated in Figure 39. Asphalt, wood, and metal roofing account for 99.1 per

Table XXIV

WIND AND HAIL DAMAGE TO IOWA FARM BUILDING ROOFING IN 1946

		Barn	Crib	Dwelling	Hog house	Mach. house	Poult. house	Misc. bldg.	Total
Wood									
Wind	D:	2542	732	2350	173	136	175	104	6212
	N:	126	39	119	15	10	15	9	333
Hail	D:	984	576	2081	468	56	240	157	4562
	N:	52	27	76	23	5	21	18	222
Asphalt									
Wind	D:	7490	1434	20494	589	168	619	2232	33026
	N:	298	74	990	32	7	42	74	1517
Hail	D:	2207	346	10798	355	105	163	1028	15002
	N:	42	15	229	9	4	11	37	347
Metal									
Wind	D:	2775	1013	209	422	404	147	42	5012
	N:	123	53	11	14	26	10	4	241
Hail	D:	93	27	27	96	87	0	30	360
	N:	5	3	1	3	3	0	1	16
Others									
Wind	D:	69	55	224	15	0	175	0	538
	N:	2	2	11	1	0	3	0	19
Hail	D:	0	0	37	0	0	35	0	72
	N:	0	0	2	0	0	1	0	3
Total									
Wind	D:	12876	3234	23277	1119	709	1116	2378	44788
	N:	549	168	1131	62	43	70	87	2110
Hail	D:	3284	949	12943	919	248	438	1216	19996
	N:	99	45	308	35	12	33	56	588
TOTAL	D:	16160	4183	36220	2118	956	1554	3593	64782
	N:	648	213	1439	97	55	103	143	2698

D - Damage
N - Number

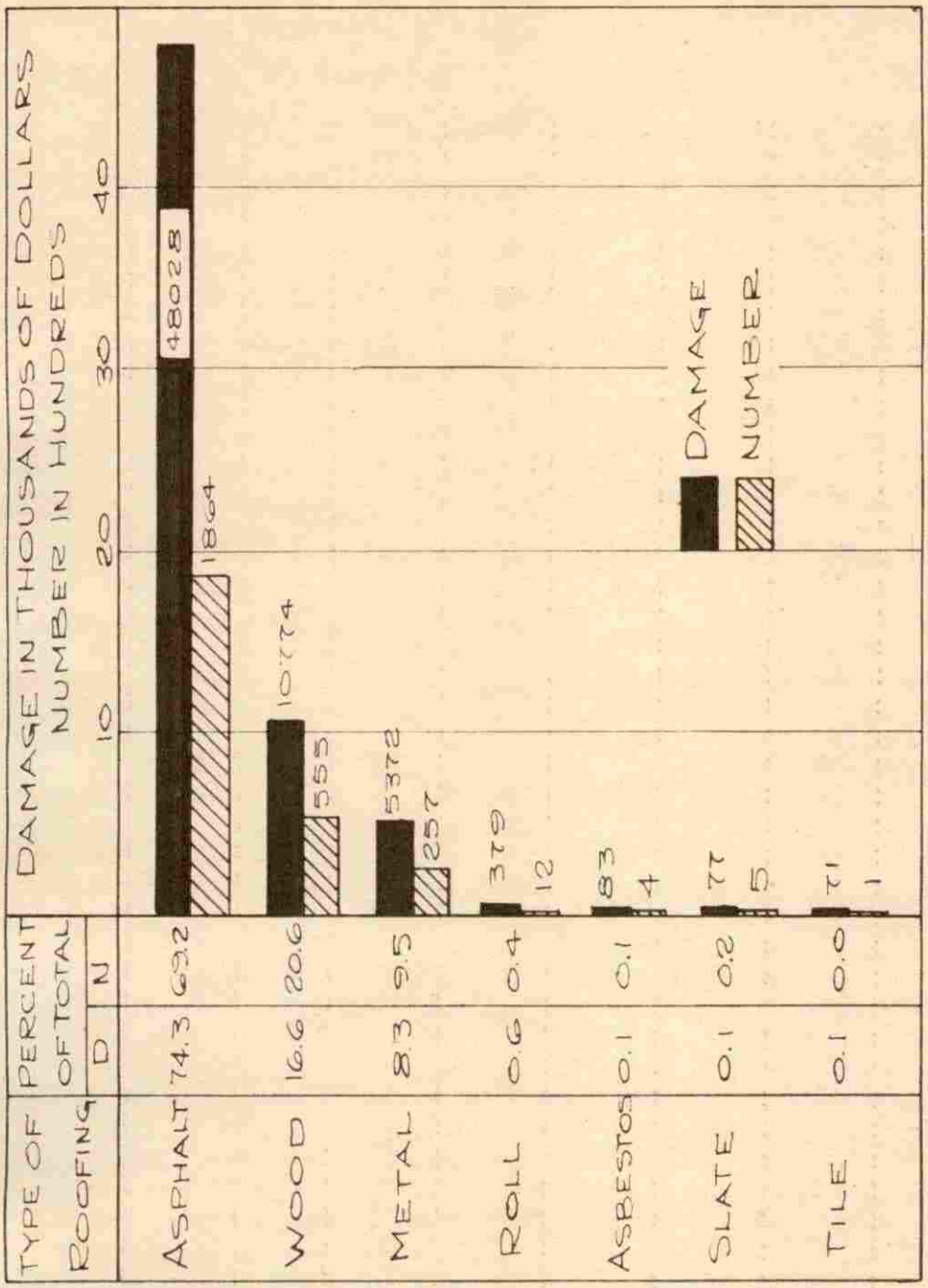

FIG. 39 WIND AND HAIL DAMAGE TO ROOFING BY MATERIAL

cent of the damage and 99.3 per cent of the number damaged.

Cause of damage

The main causes for roofing material damage are wind, hail, flying debris and falling trees. Throughout this report, reference to the term "wind damage" is used to represent damage by all causes, unless specified, due directly to wind.

Roofing damage due directly to wind causes the greatest loss, with hail second, and all other causes last. In 1946, hail caused about half as much damage to roofing as wind. This figure for hail damage may be somewhat light, since incomplete reports were assumed to have been damage caused by wind unless the date of the damage and location could be connected with a known hail storm which caused similar damages in that area. Figure 40 gives the wind and hail damage to roofing by type of material along with number of damages. There is not a noted difference between the amount of wind and hail damage to wood shingles, but with asphalt shingles the wind damage is more than double that of hail. The magnitude of wind damages to asphalt shingle roofs is $21.75, while for hail damage it is $43.25 or nearly doubled, indicating that the damage by hail is more severe.

Buildings damaged

In a statistical study of the magnitude of roofing

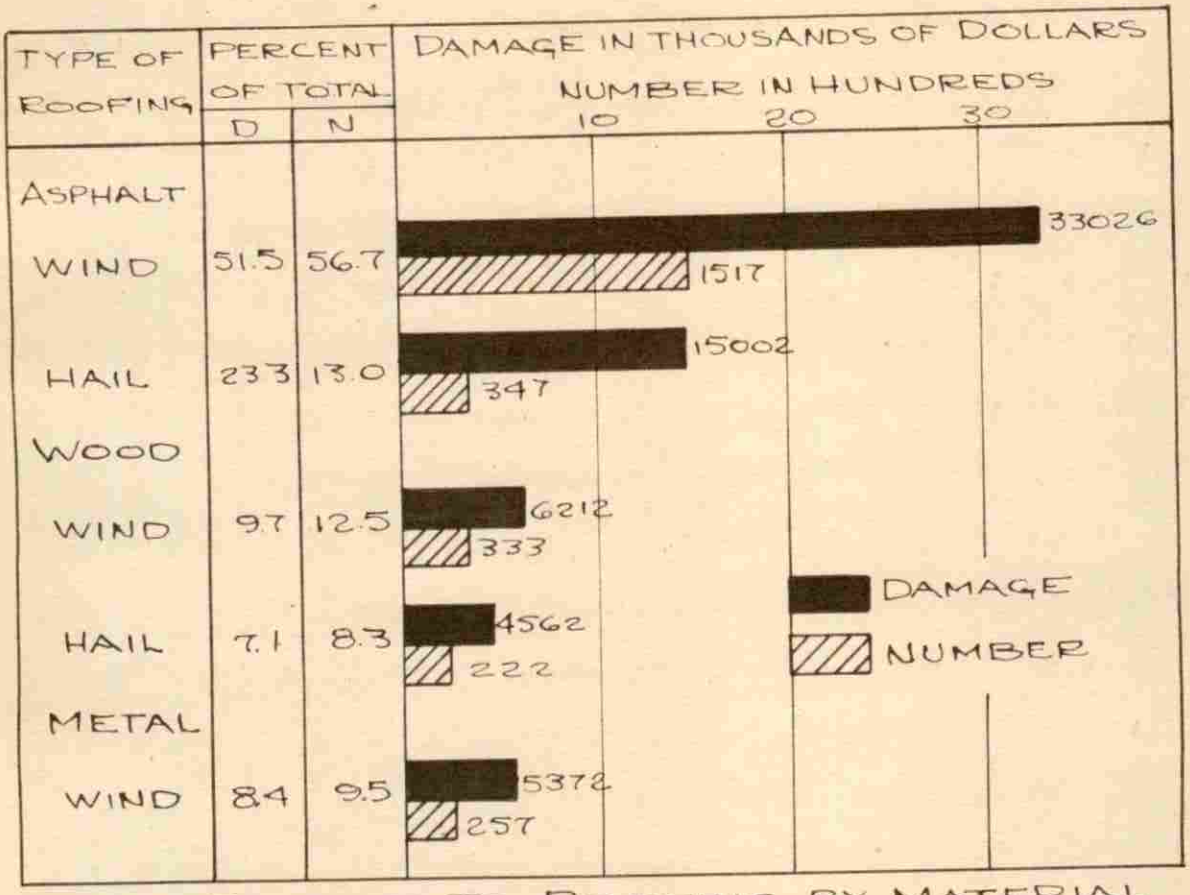

FIG.40 DAMAGE TO ROOFING BY MATERIAL AND CAUSE

material losses on various farm buildings by wind and hail, Figure 41 shows the dwelling to be the most vulnerable target. It suffered 56 per cent of the total wind and hail loss to roofing on farm structures in 1946. This can be attributed mostly to the large percentage of asphalt roofing on the dwelling as compared to the service buildings. It was brought out in Figure 38 that 65 per cent of the farm buildings having asphalt shingles were dwellings and asphalt shingles accounted for 74.3 per cent of the damage to roofing. In "A Survey of Roofing on Farm Buildings" (17) made in 1941 and 1942 by the American Zinc Institute, it was found that the area of dwelling roofs averaged 11.6 squares in Iowa, and for all service buildings, including barns, it was 9.6 squares. They also found that in 1942 the amount of asphalt roofing on Iowa farm buildings varied from 34 per cent of the total area of all dwelling roofs surveyed to 3 per cent of the roofing area of the other service buildings. As illustrated by Figure 38, there was 41.9 per cent of the number of dwelling with asphalt roofs in 1946 and 13 per cent of the number of all other buildings. This shows a marked increase in the application of asphalt shingles in a period of four to five years.

In analyzing further the wind and hail damage to roofing by type of material and type of building, in Figure 42 it is illustrated that 87 per cent of the $36,220.00 roofing damage to Iowa dwellings in 1946 was for settlement of claims

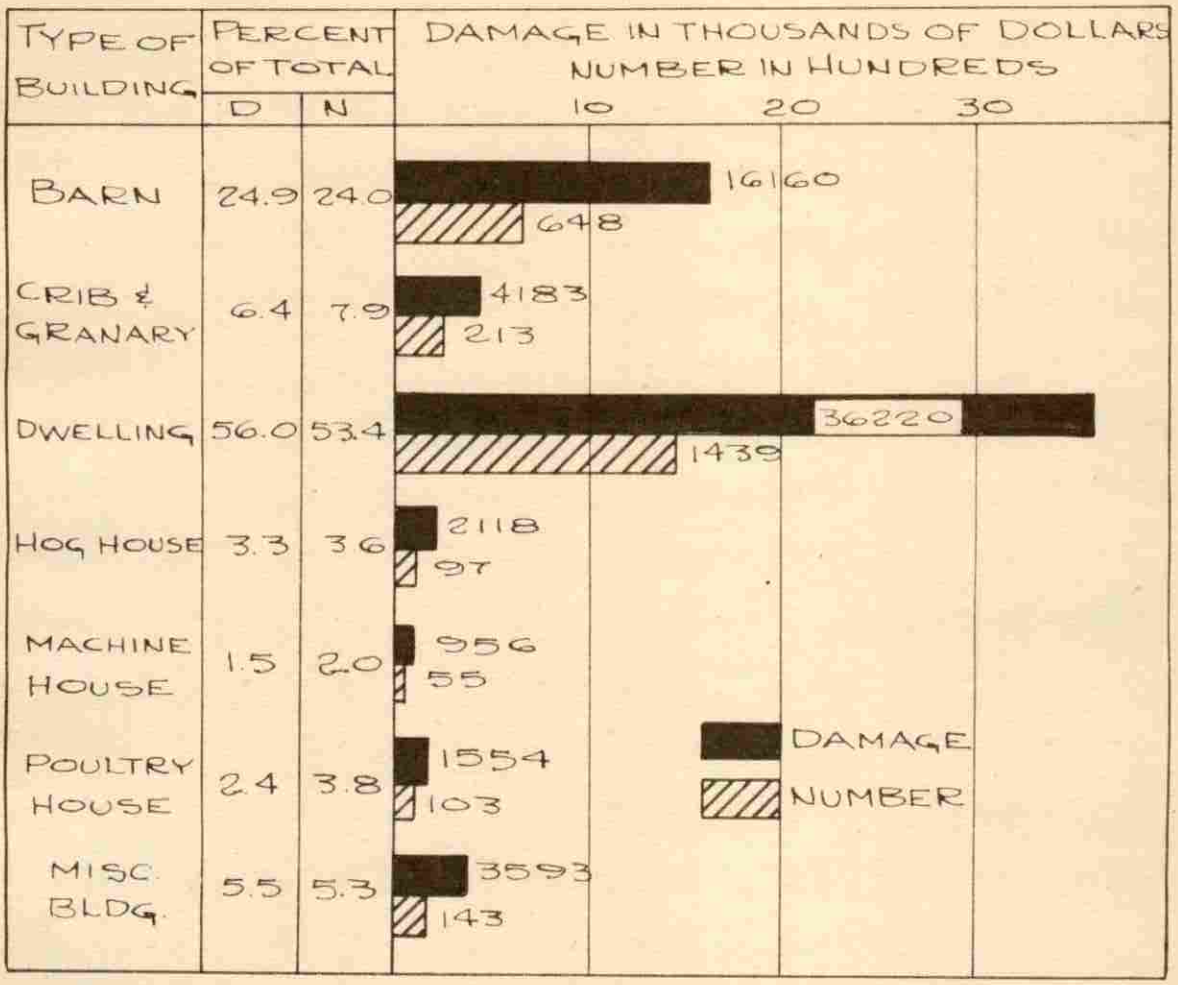

FIG. 41 WIND AND HAIL DAMAGE TO ROOFING BY BUILDINGS

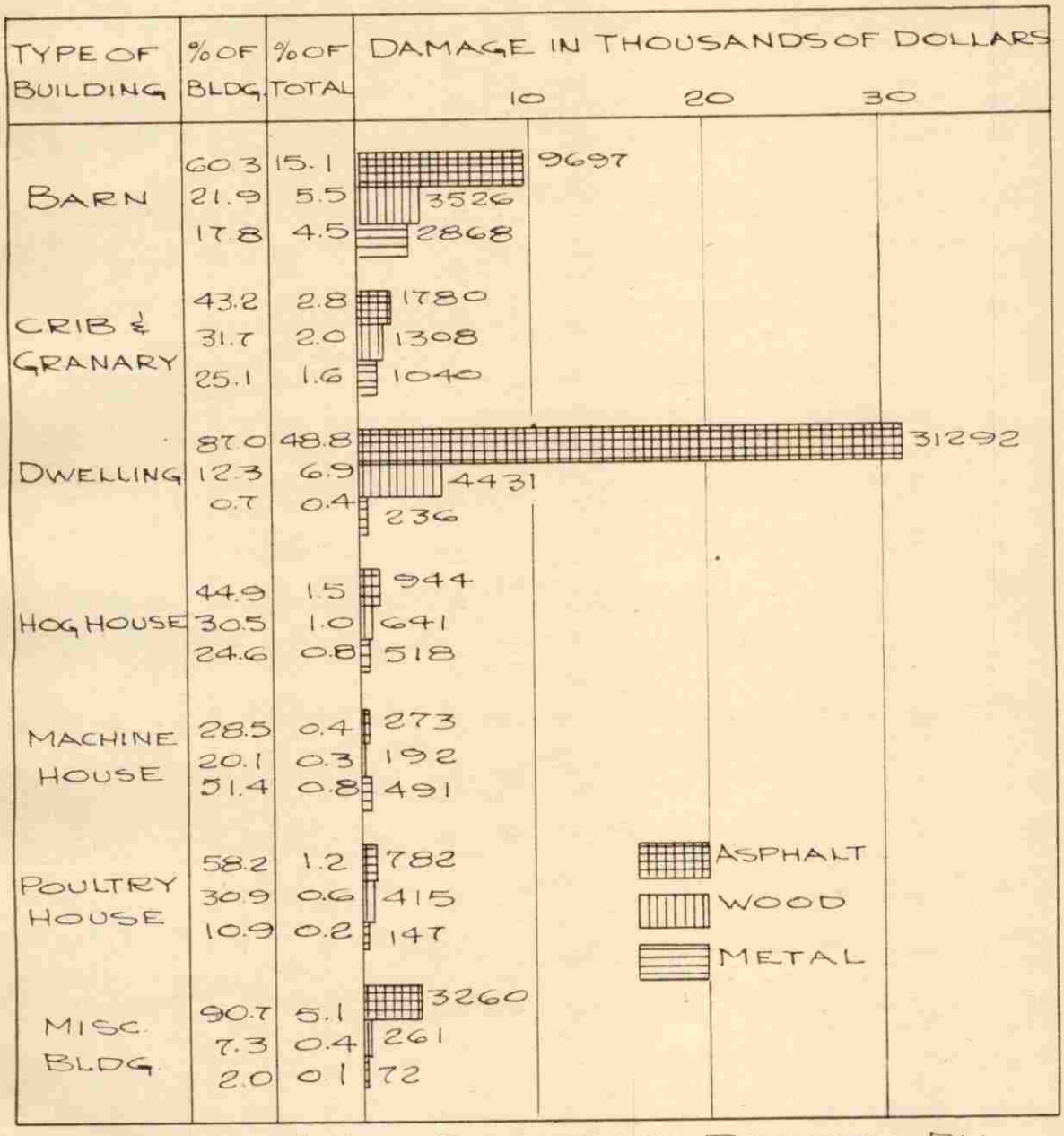

FIG. 42 WIND & HAIL DAMAGE TO ROOFING BY BUILDING AND MATERIAL

on damages to asphalt shingles. Asphalt shingles damages to barns accounted for 60 per cent of the wind damage to barn roofs. This lower percentage figure for barns, as compared with dwellings, can best be accounted for by the smaller per cent of asphalt shingle roofs on barns.

In order to analyze further the damage to asphalt and wood shingles by wind and hail, Figures 43 and 44 were prepared. Figure 43 shows the dwelling suffering 42.7 per cent of the asphalt shingle damage from wind and another, 22.5 per cent from hail, making a total of 65.2 per cent. Less than one-third of that for dwellings, 20.2 per cent of the total, was suffered by barns.

As shown in Figure 44, hail and wind damage to wood shingles on dwellings was nearly equal. The damage to wood shingles on barns by wind was greater than it was on dwellings, which is in contrast to the wind damage to asphalt shingles on the two buildings.

Age of buildings and roofing

Figure 45 shows the dwelling to be the oldest building on the farmstead, with an average age of 32.3 years. In contrast, it has the youngest roof, averaging only 14.1 years, while barn roofs average 21.6 years old and the barns themselves, 31 years old. The average age of roofs on all farm buildings was 18.9 years while for all service buildings it was 19.5 years.

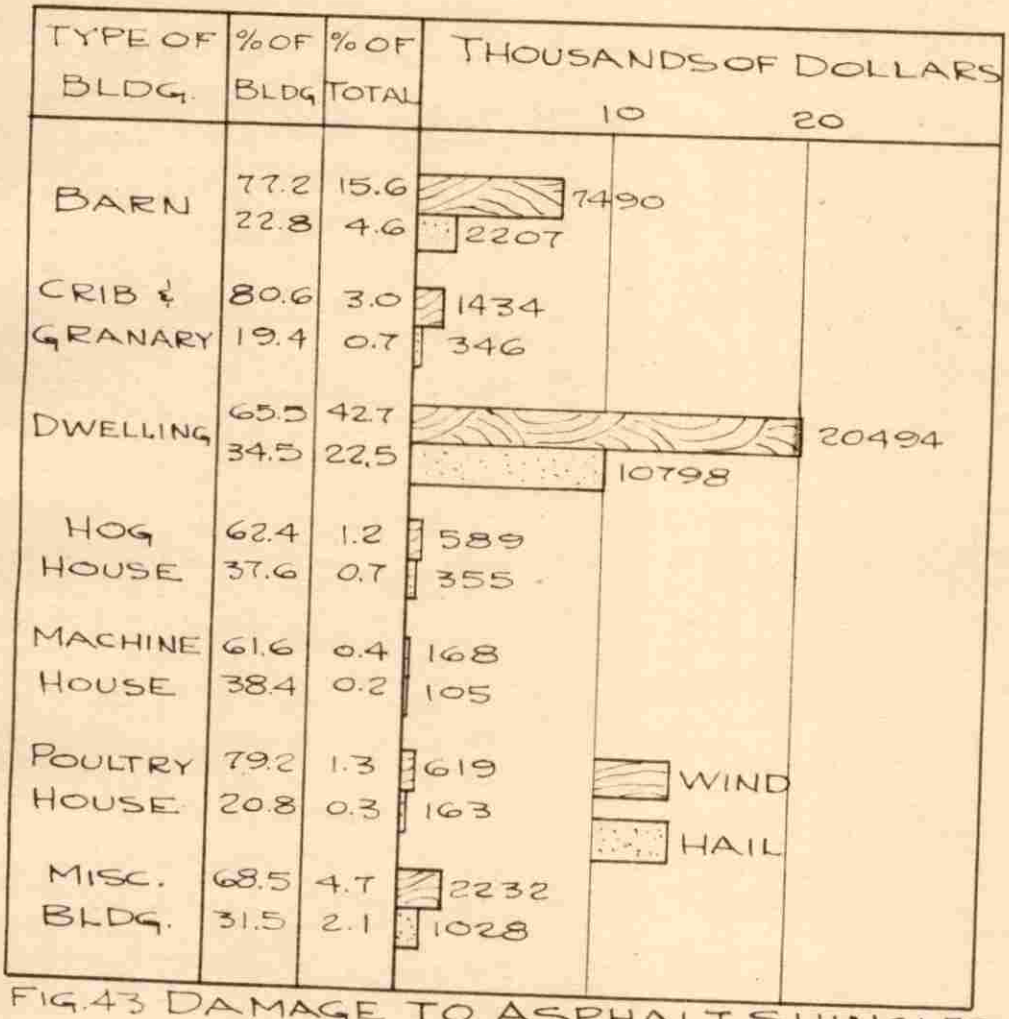

FIG. 43 DAMAGE TO ASPHALT SHINGLES BY WIND AND HAIL

TYPE OF BUILDING	% OF BLDG.	% OF TOTAL	THOUSANDS OF DOLLARS 0 10
BARN	72.2	23.6	2542
	27.8	9.1	984
CRIB & GRANARY	56.0	6.8	732
	44.0	5.3	576
DWELLING	53.0	21.8	2350
	47.0	19.3	2081
HOG HOUSE	27.0	1.6	173
	73.0	4.4	468
MACHINE HOUSE	70.8	1.3	136
	29.2	0.5	56
POULTRY HOUSE	42.2	1.6	175
	57.8	2.2	240
MISC. BLDG.	39.8	1.0	104
	60.2	1.5	157

WIND HAIL

FIG. 44 DAMAGE TO WOOD SHINGLES BY WIND & HAIL

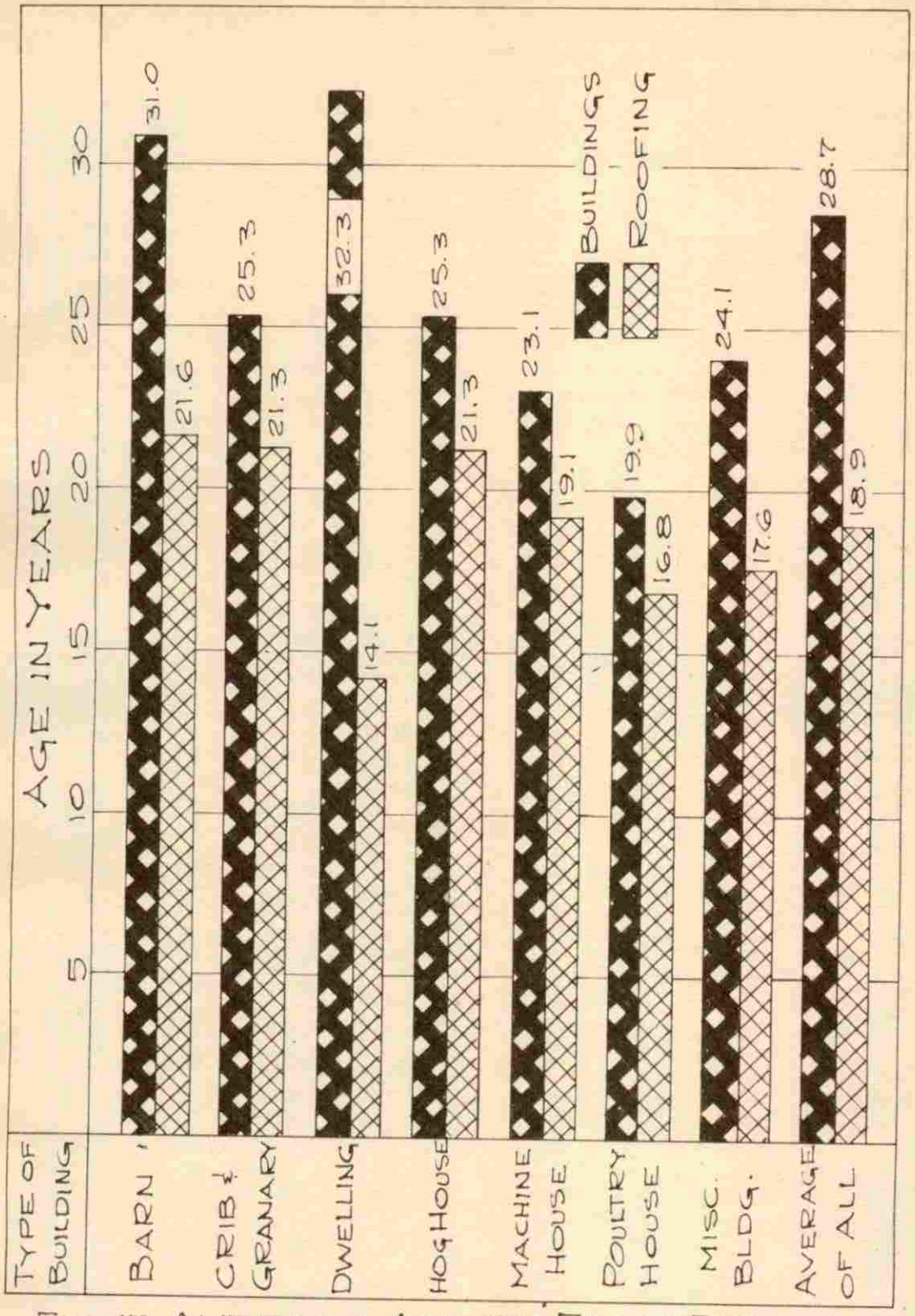

FIG. 45 AVERAGE AGE OF FARM BUILDINGS AND ROOFING IN 1946

It is the writer's opinion that dwelling roofs are generally better maintained than those of the other farm buildings. Due to the old age of the dwelling with the much younger roofing, and because of the type of roofing, asphalt shingles were more in evidence on dwellings than on the other buildings. This indicates that they have been reroofed oftener and more recently than the service buildings.

In a study of the age of roofing at time of damage, Figure 46 illustrates that asphalt shingle roofs on the average are less than half as old as wood shingles when damaged by either wind or hail. These figures are somewhat low, inasmuch as claims were not paid on asphalt shingle roofs over twenty years old, while in many cases they were on wood shingle roofs.

Figure 48 was prepared to show graphically the number of wood and asphalt shingle roofs damaged at various ages. Even though wood shingle roofs dominate asphalt shingle roofs in number by more than 2 to 1, there were only 317 wood shingle roofs of twenty years old or less damaged in 1946 as compared to 1826 asphalt shingle roofs of the same age group.

There were more asphalt shingle roofs of up to two years old damaged in 1946 than there were wood shingles up to twenty years of age.

The average age of asphalt roofing on the various types of farm structures at time of damage is fairly constant, as illustrated in Figure 47.

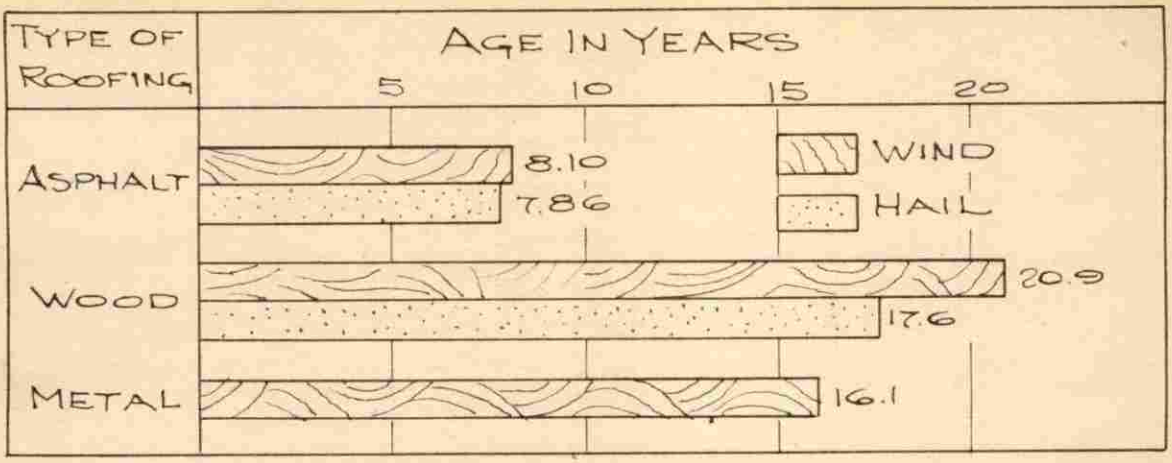

FIG. 46 AGE OF ROOFING WHEN DAMAGED, BY MATERIAL

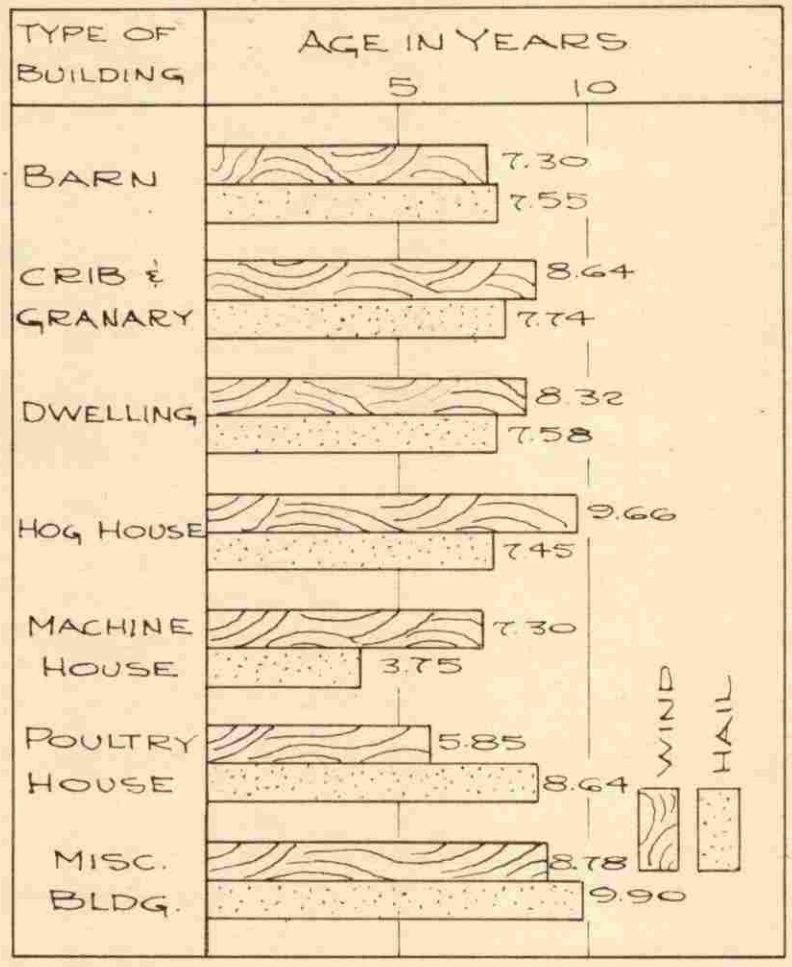

FIG. 47 AGE OF ASPHALT ROOFING WHEN DAMAGE BY BUILDING

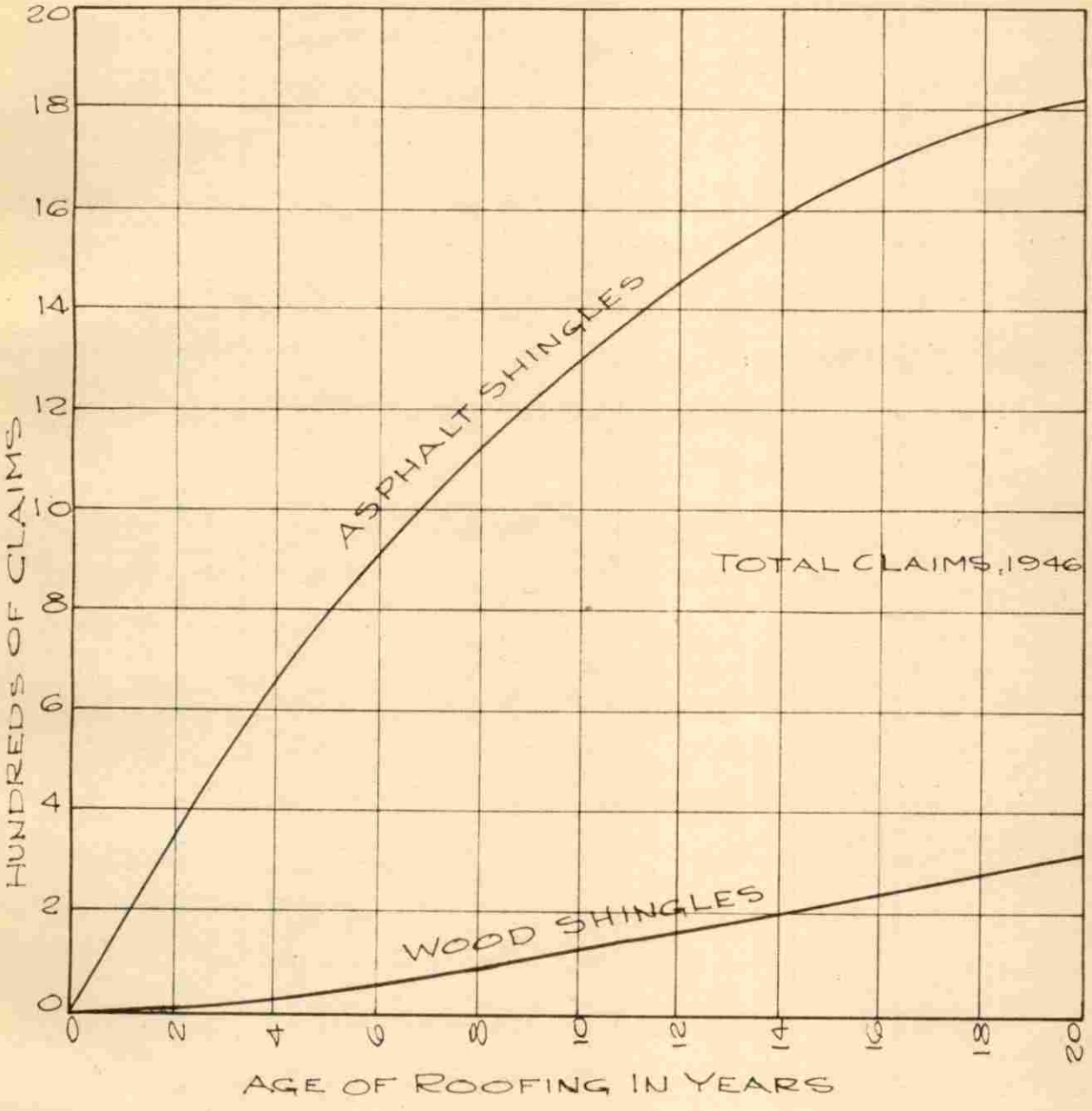

FIG. 48 ROOFING DAMAGE BY AGE OF MATERIAL

Probability of loss

In Table XXIII it is shown that only 10.90 squares out of the 64.80 squares (17) of roofing on the average Iowa farmstead were of asphalt shingles in 1946, while 46.4 squares were of wood shingles. This is a comparison of 16.8 per cent asphalt shingles by area to 71.6 per cent for wood shingles. In amount of loss attributed to each type of roofing, Figure 39 shows 74.3 per cent was to asphalt shingles and 16.6 per cent to wood shingles. In comparing percentage of damage sustained by asphalt shingles to percentage of roofing by area, 71.6 is divided by 16.8 to get 4.26; and similarly, for wood shingles 16.6 is divided by 74.3, resulting in .223. It is noted, then, by proportion, that 4.26 is to .223 as 19.1 is to 1. This proportion indicates that the probability of wind or hail damage to asphalt shingle roofing on Iowa farm buildings is 19.1 greater than for damage to wood shingle roofing.

To arrive at a probable wind loss to roofing on Iowa farm buildings if 100 per cent of the coverage consisted of asphalt shingles, Table XXV was prepared.

Column 1 of Table XXV gives the percentage of asphalt shingle roofs by number of buildings, taken from the 1946 wind study. Column 2 gives the damage to asphalt shingle roofing by type of buildings for 1946 in Iowa. The amount of probable loss in Column 3 was derived by dividing the amount

Table XXV

DAMAGE TO ASPHALT SHINGLES

Type of building	Asphalt per cent of no.	Damage in dollars	Probable damage for 100 per cent
Dwelling	41.9	31,292	74,600
Barn	12.1	9,697	80,000
Crib and granary	7.7	1,780	23,100
Hog house	9.1	944	10,370
Poultry house	13.2	782	5,920
Machine house	4.4	273	6,200
Misc. building	32.8	3,260	9,940
Total		48,028	220,130

of damage in Column 2 by the per cent of asphalt roofs in Column 1 and then multiplying by 100.

If 100 per cent of the roofing on Iowa farm buildings, as indicated in Table XXV, was asphalt shingles, the probable loss for 1946 would have been $220,130.00 for roofing alone, or 44.7 per cent of all the wind damage to farm buildings for that year. This is considering that 100 per cent of the roofing was of the same age group and of the same quality as the existing 16.8 per cent as recorded in the 1946 analysis.

Damage to Concrete Block Buildings

Type of damage

Wind damage to Iowa farm buildings is given by type of structure for each of the farm buildings in Table XXVI. It is noted that a very high per cent of all wind damage was to wood fram structures. Less than one per cent of the damages recorded for wind damage to farm buildings in 1946 was for damage to buildings constructed of concrete blocks. This percentage figure of .934 of one per cent or 84 damages does not include silos. Wind damage to the concrete block buildings, however, amounted to slightly more than three per cent of the year's total wind damage to farm buildings.

The number of concrete block buildings damaged and the resulting damage is shown in Table XXVII for the three major types of damage which accounted for 53.6 per cent of the number of damages on wind damaged concrete block buildings and 89.2 per cent of the damage to such buildings. The above percentages of damaged buildings resulting from demolition, end or side out, or roof off are very high in comparison to 8.5 per cent of the damages and 41.8 per cent of the damage which are the corresponding percentages for damage to all types of buildings from these three types of failure.

Table XXVI

WIND DAMAGE TO IOWA FARM BUILDINGS BY TYPE OF BUILDING IN 1946

	Wood frame		Stone		Brick		Tile		Stucco		Concrete block		Steel	
	Damage	No.	Dam	No	Dam	No	Dam	No	Dam	No	Damage	No	Dam	No
Barn	164,491	2,538	23	1	64	2					6,524	21	8	1
Crib and granary	38,853	1,055									258	6	413	10
Dwelling	73,785	3,530	107	6	86	4			3	1	61	3		
Hog house	18,582	426					325	1			2,848	28	10	1
Machine house	18,656	349									135	1		
Poultry house	15,264	491	10	1							609	17	7	1
Misc. bldgs.	14,854	494			34	2	257	2			317	8		
Total	344,485	8,883	140	8	184	8	582	3	3	1	10,752	84	438	13

Table XXVII

WIND DAMAGE TO IOWA FARM BUILDINGS BY TYPE OF DAMAGE AND STRUCTURES IN 1946

		Barn	Crib	Dwelling	Hog house	Mach. house	Poult. house	Misc. bldg.	Total
Demolition Wood frame	D:	68904	13910	1,200	9390	9279	7081	3970	113734
	N:	90	46	1	39	43	49	36	304
Demolition Conc. blk.	D:	3600			1496		100	100	5296
	N:	2			3		1	1	7
Demolition Other types	D:		125						125
	N:		1						1
Demolition Total	D:	72504	14035	1,200	10886	9279	7181	4070	119155
	N:	92	47	1	42	43	50	37	312
Roof off Wood frame	D:	8322	1686	369	890	1829	590	364	14050
	N:	109	39	21	14	22	17	13	235
Roof off Conc. blk.	D:	716	81		151		154		1102
	N:	3	2		3		3		11
Roof off Other types	D:	25	31		325			164	545
	N:	1	3		1			1	6
Roof off Total	D:	9063	1798	369	1366	1829	744	528	15697
	N:	113	44	21	18	22	20	14	252
Side out Wood frame	D:	6658	993		817	544	648	241	9901
	N:	95	16		19	13	18	10	171
Side out Conc. blk.	D:	1682			954	135	319	117	3207
	N:	7			9	1	7	3	27
Side out Other types	D:	8							8
	N:	1							1
Side out Total	D:	8348	993		1771	679	967	358	13116
	N:	103	16		28	14	25	13	199
TOTAL Wood frame	D:	83884	16589	1,569	11097	11652	8319	4575	137685
	N:	294	101	22	72	78	84	59	710

Continued on next page

Table XXVII (Cont'd)

		Barn	Crib	Dwelling	Hog house	Mach. house	Poult. house	Misc. bldg.	Total
TOTAL(cont'd):									
Conc.blk.	D:	5998:	81:		2601:	135:	573:	217:	9605
	N:	12:	2:		15:	1:	11:	4:	45
Others	D:	33:	156:		325:			164:	678
	N:	2:	4:		1:			1:	8
TOTAL	D:	89915:	16826:	1,569:	14023:	11787:	8892:	4956:	147968
	N:	308:	107:	22:	88:	79:	95:	64:	763

D - Damage N - Number

Magnitude of damages

In considering amount of damage per damage to concrete block buildings, it was found to be much higher than for the average on buildings of all types, for which wood frame buildings make up a large majority. In 1946 there were seven concrete block buildings demolished with an average loss of $757.00 per building, while the average damage for wind demolition of all types of buildings in 1946 was $388.00. This shows the average loss for demolition of concrete block buildings to be about twice that of all types.

The average loss for concrete block buildings having an end or side blown out or a roof off was $118.40 and $101.00, while for all types of buildings it was $63.70 and $68.80, respectively. In calculating the magnitude of loss per damage on wind damaged concrete block buildings, it was found that when all types of damages were included, such as windows

broken and doors or shingles damaged, the amount was $128.00 as compared to an average of $38.90 for all damages to all types of buildings in 1946.

The greatest difference is shown in the averages for damage to barns. The damage to concrete block barns was over four and one-half times that for all types of barns. The damage per damage to concrete hog houses and machine houses are over 100 per cent of the average for all types.

The above data show that there is a significant difference in magnitude of damage to concrete block buildings and that the types of damages which account for a large portion of the losses are three; namely, demolition, end or side out, and roof off. These three types of damages are very closely related and tend to point to the fact that the nature of the damage to concrete block buildings is usually the loosening of the roof at the plate from the block wall. This results in the roof being blown off and in doing so, dragging over a wall or two with it. The classification of the type of damage among the three types, then, depends on the extent to which the damage progressed. If the wall loosened first and blew out, it would in most cases be classified under end or side out; if the roof loosened from the wall and blew part way or all the way off, it would be classified as roof off; and if the total damage was sufficient it would be classed as total demolition.

Group Wind Damage

Analysis

In analyzing group wind damage there are many factors which should be considered. The number of buildings that are damaged simultaneously on one farmstead by the same windstorm depends on the type of storm, design and condition of the various buildings as to their wind resisting ability, and shelter of various buildings by others or by wind breaks. A freak tornado might demolish only one building and leave the others untouched, while a straight wind of high velocity might overturn a small unanchored poultry house, blow the barn out of plumb, and damage the shingles on two or three other farmstead buildings. The dwelling, which it is believed generally has more favorable wind breaks than the other buildings, may not be damaged at all. The good construction of the dwelling also proves it more wind resistant than the other farmstead buildings.

Of 8,689 damages to farm buildings recorded in the group wind damage survey for 1946, 54 per cent were for single damages. That is, only one building of the farmstead, generally covered by one insurance policy, was damaged at any one time. These single damages accounted for 48.3 per cent of the total damage to farm buildings. Table XXVII lists

numerically and Figure 49 shows graphically the percentage of damage and number of damages occurring in groups of varying size from one to eight buildings. The curve representing the losses paid or damage suffered is somewhat straighter than the one for number of damages. This indicates the magnitude of the damages in the smaller groups tends to be somewhat less than for losses involving a larger number of the farmstead buildings. This increase in magnitude, which is somewhat proportional to the number of buildings damaged, seems normal because in most cases it is believed that where a wind is severe enough to cause a large damage to one building there would also be resulting damage of some type to other buildings of the farmstead.

Group wind damage by type

Table XXVII segregates the group wind damage by type of damage. The group damage trend is somewhat the same for all types of damage except those caused by hail. The outstanding one of this exception is damage to paint and siding which is caused almost entirely by hail. For this type of damage it is noted that there were more damages involving groups of two, three, and four buildings than of only one building. Hail accounted for much of the damage to glass and shingles, too, but not enough to raise the number of damages involving two or three buildings above the number for single building damages.

Table XXVIII

GROUP WIND DAMAGE TO IOWA FARM BUILDINGS
IN 1946

		Number of buildings per group								
		1	2	3	4	5	6	7	8	9
Addition	D:	3109	1112	908		8	176		17	
	N:	34	11	6		1	2		1	
Cornice	D:	680	117	91	23	19	8			
	N:	42	7	5	2	1	1			
Cupola	D:	3624	814	224	35	26		25		
	N:	157	42	12	1	2		1		
Demolition	D:	39104	19835	13595	15015	14775	5231	9150	850	1600
	N:	135	60	31	28	25	9	14	3	7
Doors	D:	15284	5480	1470	619	388	185	66	99	10
	N:	918	357	103	46	24	7	8	7	1
End or side out	D:	5739	1824	1595	535		6			
	N:	83	26	15	7		1			
Glass	D:	8453	3433	1393	769	415	544	325	158	198
	N:	773	409	175	89	38	38	25	9	9
Misc. dam.	D:	3155	1383	362	366	426	298	77	5	123
	N:	93	48	23	16	9	9	4	1	6
Off found.	D:	11490	5946	2257	927	546	653	146	409	16
	N:	189	85	49	31	17	12	5	10	1
Out of plumb	D:	26756	5213	4541	1053	1265	631	1233	258	199
	N:	347	104	52	28	28	16	15	8	4
Paint and siding	D:	1001	1874	1438	1588	1023	1369	437	296	648
	N:	40	93	66	60	30	34	15	13	23
Roofing	D:	40203	14807	6841	3936	2254	2163	813	1792	609
	N:	1669	618	315	154	78	56	21	33	25

Continued on next page

Table XXVIII (Cont'd)

		Number of buildings per group								
		1	2	3	4	5	6	7	8	9
Roof off	D:	11005:	3287:	1605:	2052:	66:	600:	424:	75:	
	N:	204:	63:	25:	11:	5:	6:	4:	1:	
TOTAL	D:	169603:	65125:	36320:	26918:	21220:	11864:	12696:	3959:	3403
	N:	4693:	1923:	877:	473:	258:	191:	112:	86:	76

D - Damage
N - Number

The fact that over half of the damages recorded and nearly half of the damage in 1946 were for claims involving only one building of a farmstead is quite amazing. This indicates a great inconsistancy in the wind resistance of farm buildings. Even in demolition of farm buildings, 43.4 per cent of them were the only damage resulting on farm buildings covered by one policy. Normally, all of the buildings of insurable condition on a farmstead are covered by one policy. It is believed that this is due to the fact that most of the buildings damaged by wind are of sub-standard construction. It can hardly be concluded that a certain building could not have been prevented from being demolished by a straight windstorm when it was the only building of the farmstead to be damaged in any way or manner.

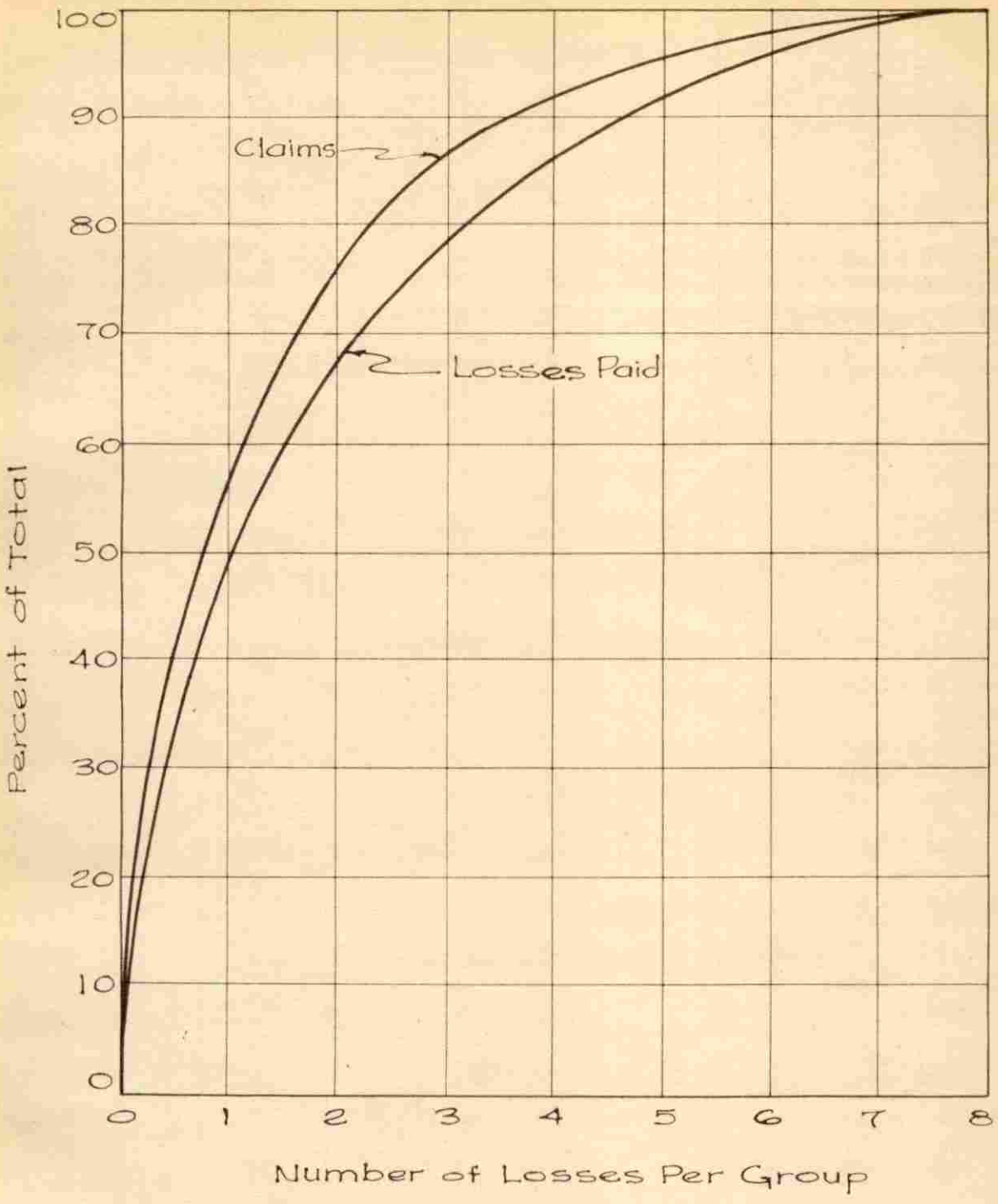

Fig. 49 GROUP WIND DAMAGE TO FARM BUILDINGS IN IOWA

Age of Iowa Farm Buildings when Damaged in 1946

Damage by type of building

In 1946 the average age for all farm buildings damaged by wind at time of damage was 28.7 years, as shown in Figure 45, while the average age for the roofing on those same buildings was 18.9 years. The oldest building of the farmstead at time of damage was the dwelling. They were an average of 32.3 years old. In contrast to the age of the dwellings, the roofing was the youngest of any other on the farmstead. The dwelling roofs averaging 14.1 years old were 2.7 years newer than on any other building. The roofing on the poultry houses was next in age averaging 16.8 years, while the poultry houses themselves averaged only 19.9 years, being the youngest of any of the farmstead buildings.

It might be thought that, due to the age of the dwelling, it required reroofing in more cases in the last few years than the other buildings of the farmstead; but in consideration of the age of buildings alone it is noted that the average age of barns was only 1.3 years less than for dwelling and the roofing was 7.5 years older. Generally speaking, the roofing on all buildings averaged from four to 10 years younger than the building which it was on, except for dwellings which showed a difference of 18.2 years.

Age of buildings by type of damage

There was not a noted difference in the ages of buildings when damaged, by type of damage. The average for demolition of buildings as shown in Figure 50 was 26.6 years and for buildings off foundations, 25.9 years. The buildings were the youngest on the average when damaged by the two ways mentioned above. Buildings having cupolas blown off were the oldest group, averaging 33.4 years. This type of damage was almost entirely to barns and they averaged 31.6 years old for all types of damage. This shows that barns having cupolas blown off were somewhat older than those suffering other types of damage.

Buildings suffering roofing damage were an average of 28.7 years old which is the average age for all buildings at time of all damages. The age of roofing, however, was only 11.1 years old at time of damage, which was much younger than that on other buildings suffering damage other than to roofing.

Due to the different types of buildings involved in each type of damage, the average ages are pretty near even for each type of damage.

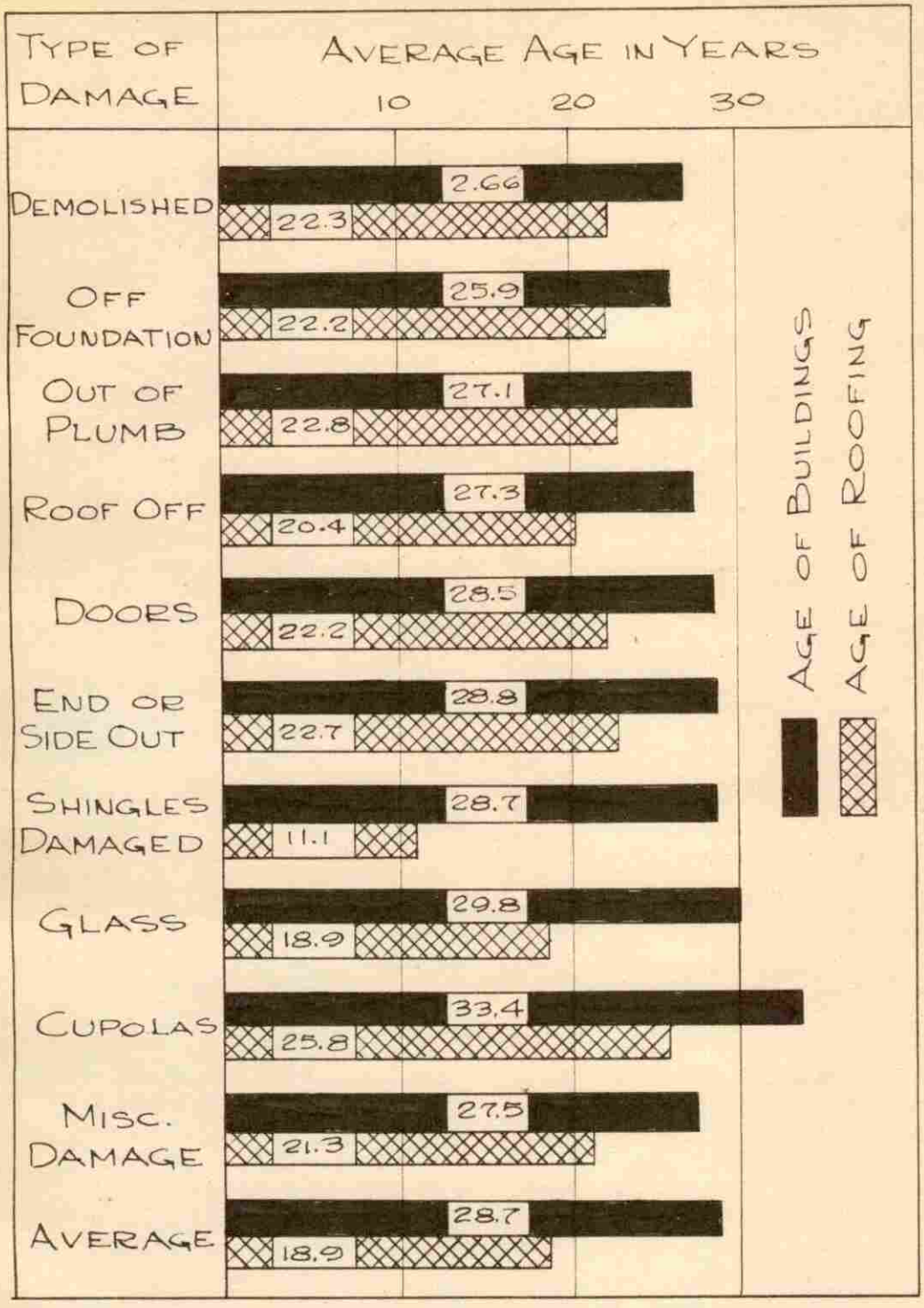

Fig.50 AGE OF FARM BUILDINGS IN IOWA WHEN DAMAGED

DISCUSSION

It has been brought out by this analysis of wind damage to Iowa farm buildings during 1946 that a great majority of the damages are preventable. The main weaknesses are non-wind resistant roofing, weak joints, insufficient wind bracing, and improperly hung doors, which can all be remedied through continued inspection, proper maintenance and repair.

Roofing on farm buildings has proved to be very vulnerable and a poor risk for insurance companies. Only through the proper application of high quality heavyweight roofing will the damage be appreciably lowered. Factors to be considered in purchasing and applying shingles are coverage, headlap, sidelap, exposure, and weight per unit area of roofing material, and more particularly, per unit area of finished roof. The American method of laying asphalt shingles furnishes the best coverage in utilization of individual shingles (16). A finished roof of standard weight individual asphalt shingles laid the American method will result in a 250 lb. per square roof. The weight of a finished roofing material per unit area furnishes a good measure of the quality because, generally speaking, the greatest weights provide the best coverage, headlap, sidelap and exposure.

The proper application of roofing is very important.

Improper nailing or an insufficient number of nails will weaken a high quality roofing material so it will not withstand wind damage for a reasonable length of time.

In the prevention of demolition, buildings out of plumb, roofs off, and off foundations, it is a matter of proper fastening and wind stable joints. Recommended building plans should be followed in the design and construction of farm buildings, and all buildings should be inspected periodically to catch and correct minor failures in buildings before they develop into major ones causing severe damage and economic loss to the farm operator and owner. Damage to doors could be nearly eliminated if they were designed and hung properly with latches for use in keeping them fastened open or shut to prevent swinging.

A program for the prevention of wind losses can only be successful if it reaches the farm operators, the farm builders, and lumber dealers. They must be made conscious of the probable wind damage and the poor risks which sub-standard material and improper methods of application present.

It is recommended that a continued statistical wind loss study of at least 10 years be made, similar to the one for 1946, in order that accurate trends in types and causes of damage may be determined. Such data could then be used for educational and promotional programs in the prevention of wind damage. It is further recommended that a detailed study

including personal observation of cases, be made of the wind damage to asphalt shingles to determine accurately the cause of failure and how it can be prevented.

SUMMARY

1. The farm building investment in Iowa was reviewed.

2. The various farming areas of Iowa were investigated as to their average investment in farm dwellings, and in all farm buildings; average amount of windstorm risk in force over a twenty-year period; and gross profits per farm and per worker.

3. The magnitude of wind damage to Iowa farm buildings over a two-year period was studied.

4. The expenditure for farm building materials in Iowa was discussed.

5. A system was devised for the tabulation of wind data, and tables set up for a continued annual study of wind losses.

6. The distribution of wind damage to Iowa farm buildings from 1927 to 1946 was tabulated, in an attempt to locate storm areas in the state if there are any.

7. A careful study was made of the type of damage caused by the 1946 windstorms.

8. The magnitude of loss and number of damages suffered by the various types of farm buildings were investigated.

9. The various causes of damage were studied.

10. Constructional damage, due directly to wind, was discussed.

11. Demolition of buildings was studied.

12. Buildings blown out of plumb were discussed.

13. A comparison of wind losses with those of the period 1930-33 was made to determine any trends in type of damage or of buildings damaged.

14. An investigation of the distribution of wind damages by magnitude of losses paid was made.

15. The hail damage to Iowa farm buildings in 1946 was analyzed.

16. The distribution of wind and hail damage by month of the year was studied.

17. A thorough investigation was made of the general windstorm of April 3 and 4, 1946.

18. Wind damage to roofing by type of material, magnitude of damage, and age of roofing when damaged was investigated carefully to determine the wind resistance of various types of roofing and probability of loss.

19. Wind damage to concrete block buildings was reviewed.

20. Group wind damage to Iowa farm buildings was analyzed.

21. The age of Iowa farm buildings when damaged, by type of building and damage, was determined.

22. The prevention of wind damage was discussed.

CONCLUSIONS

The conclusions drawn from this analysis are as follows:

1. The various farming areas of Iowa vary similarly in farm building investment, expenditure for farm building materials, average windstorm risk in force, and average income per farm and worker.

2. The annual wind losses have been rising steadily since 1940; probably due in part to the lack of maintenance and proper repair during the past few war years.

3. Over a twenty-year period there appears to be a slight concentration of wind damage in the northwest corner of the state as compared with the southeast and east central sections.

4. Wind damage in 1946 was somewhat lighter than for the twenty-year average with the heaviest damage being in the south central portion of the state.

5. Demolition, damaged roofing, and buildings out of plumb accounted for over two-thirds of the constructional damage.

6. Damaged machinery, due mainly to improper care and storage, accounted for a significant portion of the wind damage to farm property.

7. Causes other than the direct action of wind accounted

for 16.6 per cent of the total damage and is significant in the prevention of wind damage to farm property. Falling trees could be nearly eliminated through proper trimming and removal of the weak ones near buildings; also, farm machinery should not be parked for permanent storage in wind breaks.

8. The barn which suffered over half of the damage to farm buildings is lacking in sufficient wind bracing which would prevent it being blown out of plumb so readily and eventually demolished.

9. A majority of the 13 per cent of the total wind damage to dwellings was to roofing and could be eliminated to a great extent with the proper application of a wind resistant roofing material.

10. Dwellings are fairly resistant to major structural failures accounting for only one per cent of the demolition of buildings, but they suffer a great many minor damages, such as damaged doors, windows and roofing which could be reduced significantly through proper inspection, maintenance and repair.

11. The lower valued barns of poor construction and improper design were demolished most frequently.

12. The only significant wind damage trend to farm buildings since 1930-33 was the increase of damage to dwelling, being accounted for mainly by the utilization of less wind resistant roofing.

13. Small damages contributed a large portion of the wind damage to farm buildings, the average magnitude being $39.70 in 1946 with over ten per cent of the total number being for $5.00 or less.

14. Hail damage is mainly of three types; damage to roofing, glass, and paint and siding.

15. A straight general cyclonic type windstorm with a maximum of 70 miles per hour is not of a building demolition velocity; rather, a type reaching to a great number of minor weaknesses such as roofing, doors, and wind bracing.

16. The weaknesses of concrete block buildings to resist wind are the lack of wall stiffness and sufficient anchorage of the roofs to the walls at the plate.

17. The great number of single damages on farmsteads, including 43.4 per cent of the buildings demolished, indicates that many buildings are being damaged and demolished apparently because of preventable weaknesses, while the other buildings of the farmstead are not damaged in any degree.

18. Damage to roofing moved from third place in magnitude of damage in 1930-33 to second place in 1946.

19. Roofing proved to be 3.5 times as vulnerable to wind damage in 1946 as in the period 1930-33, indicating the widespread application of a less wind resistant roofing material during the last few years.

20. The dwelling presents the main roofing problem brought out by the facts that 41.9 per cent of the damaged

dwellings were roofed with asphalt shingles which accounts for 65 per cent of all the asphalt single roofs on farm buildings; and that 56 per cent of all roofing damage is to the dwelling, 87 per cent of it being to asphalt shingles.

21. Inasmuch as asphalt shingles accounted for only 16.8 per cent of the Iowa farm buildings roofing by area in 1946 as compared to 74.3 per cent of the total damage to roofing, the probability of wind and hail damage to asphalt shingle roofing was 19.1 times greater than for damage to wood shingles.

22. If 100 per cent of the roofing material on Iowa farm buildings was asphalt shingles in 1946, the probably loss would have been $220,130.00 for roofing damage alone, or 44.7 per cent of all wind damage to farm buildings for the year.

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